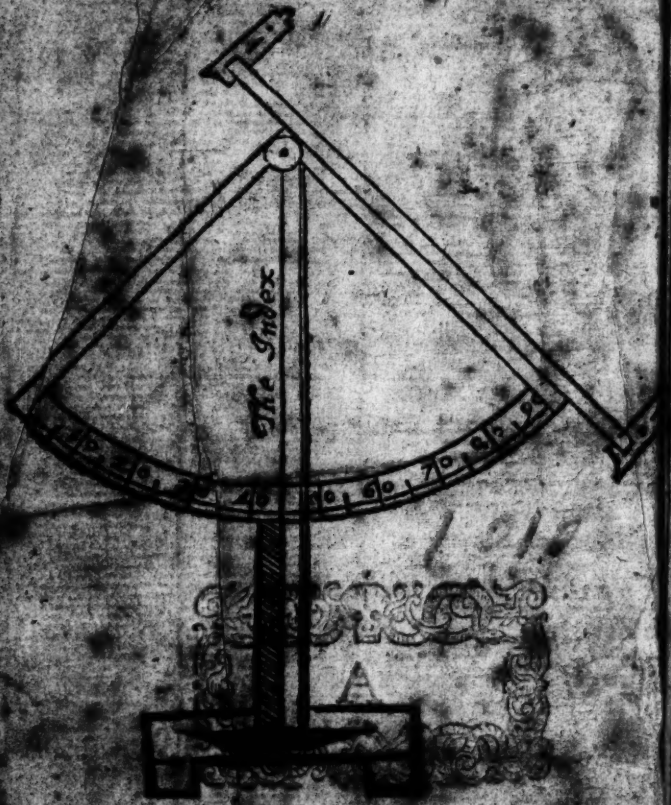
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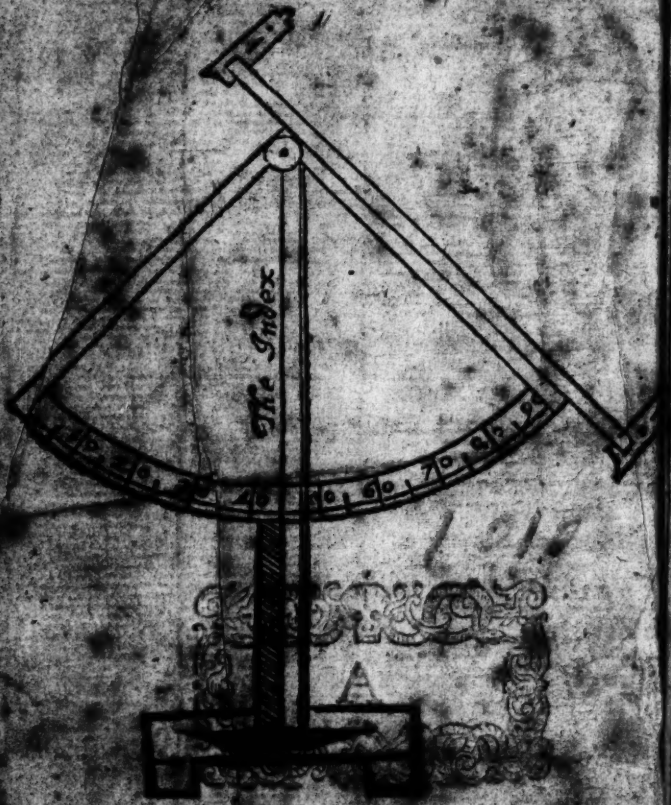
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Planometria:

OR,

The whole Art of SURVEYING OF LAND:

Shewing the Compoſition, and uſe of all the moſt neceſſary Inſtruments thereunto belonging: Eſpecially of the Plain Table, by which may be performed all the uſes of the Theodolite, Circumferencor, or any other Inſtrument.

With the uſe of a Table of *Sines* and *Logarithmes*, for the exact and ſpeedy taking of Heights, Depths, and Diſtances, whether acceſſible or inacceſſible.

With the manner of taking the plot of any Field or other incloſure ſeverall wayes, and how to take the plot of a whole Mannor, to caſt up the content thereof, and to reduce the plot unto any proportion.

Whereunto is added by way of an Appendix, a ſhort method ſhewing how to meaſure regular Solids, as Timber Stone or the like: Alſo how to meaſure taper-grown Timber, and to finde the content of any Timber Tree as it groweth.

By OLIVER WALLINEY.

London, Printed for *Nathaniel Brooks*, at the Angel in Cornhil.

Planometria:

OR

The whole Art of SVRVEYING OF LAND:

Shewing the Composition, and use of all the most necessary Instruments, [illegible] belonging: Especially of the Plain Table, by which may be performed all the uses of the Theodolite, Circumferentor, or any other Instrument.

With the use of a Table of Sines and Logarithmes [illegible] and [illegible] of Heights, Depths, and Distances, [illegible] accessible, [illegible] Whereby [illegible] the plot of any [illegible] or [illegible] all waves, and how to take the plot of a whole manner, to cast up the contents of it, and to reduce the plot unto any proportion.

Whereunto is added by way of an Appendix, a [illegible] shewing how to measure regular [illegible] Timber stone or the like: Also how to measure [illegible] Timber, and to [illegible] the content of any Timber [illegible] as ingroweth.

BY OLIVER WALLINEY.

London, Printed for Vaturas [illegible] Aegyl in Cornhill.

To the Reader.

Courteous Reader,

THou art here presented with a short Treatise of the Art of Surveying of Land, *a thing most necessary to be known & practised by every man who intendeth either to sell or purchase. I am not ignorant how many have written hereof already in the English Tongue, but the scarcity of Books of this subject (at this time wherein there is such a necessity) hath been the sole motive which induced me to divulge the following Treatise; which is so gradually composed, that the meanest capacity (with frequent and carefull practice) may attain to the full understanding of the Geometricall part of the whole Art, and in short time become an exact and able proficient therein.*

In the following work I have so methodically proceeded throughout the same, that the Reader may freely go on without any obstacle, as the interposition of any other Author, or the like.

In the first place I have described all the most necessary Instruments that have from time to time been invented, by the most ingenious Artists of all Ages, for the propagating of so Noble and necessary a Science: All which Instruments (as the Plain Table, Theodolite, *and* Circumferentor) *I have reduced to one, and made the* Plain Table *capable of all the uses of these, or any other Instrument hitherto invented for Surveying without any prejudice or intricacy in the use thereof.*

2 *For the avoyding of tedious Multiplications and Divisions, in the taking of Heights and distances, I have added a short Table of* Sines *and* Logarithmes, *by which more may be performed in the space of one houre, then by the naturall numbers or vulgar Arithmetick can be in six; and to explain the use thereof I have added the Doctrine of right*

tightlined Triangles, and applyed them to the taking of heights and distances.

3 *I have shewn how to take the plot of any plain field several all wayes.*

4 *There is the manner of measuring regular Figures, and casting up the content of any plot whatsoever, also the separation and division of Lands both Arithmetically and Geometrically.*

5 *Is shewn how to take the plot of a whole Manner, and to protract the same.*

Lastly, *Is added (by way of an appendix) a short method how to measure Solid bodies, as Timber, or stone, with the manner how to measure taper-grown Timber, and to finde the content of any Timber tree as it groweth.*

In all which I have used all the brevity I could imagine, yet have made every thing so plain that men of the meanest apprehensions may understand the same.

The work I confesse might have been more refin'd had time permitted, however such as it is, I present it to thy friendly acceptance, and rest,

Your assured friend,

Oliver Wallinby.

IN the following Treatise we have omitted to insert the sign of any Instruments therein expressed, in respect it could give little satisfaction to the Reader, and because any Instrument mentioned in this book, as also all other Mathematicall Instruments whatsoever, are exactly made by Mr. *Anthony Thompson*, neer Smith-field.

If any bee ignorant in the art of Arithmetick he may peruse Mr. Moors Arithmetick now published, in which he shall receive full satisfaction in all the parts thereof.

The Art of SVRVEYING OF LAND:

CHAP. I.

Of the most necessary Instruments appertaining to Survey.

AMong the many Instruments that have from time to time been invented for the practise of Survey, these four have been in most esteem. 1 The *Theodolite*, 2 The *Circumferentor*, and 3 The *Plain Table*; and for as much as these three are grounded upon one & the same principle, they have been all united and made as one Instrument, *viz.* The *Plain Table*. Now for as much as in the practicall part of Survey, we intend onely to make use of the *Plain*

Table (as it is now framed) being the most generall Instrument of any other, I shall therefore first in generall terms, deliver the severall parts of which the other two are framed, and then particularly describe the severall materials, of which a *Plain Table* is composed, that so my Surveyour may take his choise, and being well exercised in the use of one Instrument, he cannot be ignorant of the application of that to any of the other, for in many cases one Instrument may make a quicker dispatch, and be altogether as exact as another, and in laying down of a spacious businesse, I would advise him to use the *Circumferentor*, or *Theodolite*, and for Townships, and small inclosures the *Plain Table*, which (as I said before) contains both the other, and therefore may very well supply the want of both or either of them, as in my description of them severally I shall make appear.

Chap. II.

A Description of the Theodolite, *and it's severall parts.*

THis Instrument consisteth of four Parts, first, The *Planisphere*, or *Circle*, whose limbe is devided into 360 equall parts, called degrees, without which it were fitting to have drawn six concentrick

trick *Circles* (not equidistant, Master *Norwood* having sufficiently detected that errour in *pag.* 81. of his *Architecture Military*) with *Diagonals*, by which the parts of a degree are distinguished. The second part of this Instrument is the *Geometricall Square*, described upon the former *Planisphere*, within the *Circle*, whose use with the help of the *Index*, is chiefly to finde *Lengths*, *Bredths*, & *Distances*. The third part of this Instrument is a *Semicircle* or *Quadrant*, perpendicularly erected, and artificially contrived upon the *Index*: whose limb is divided (if a *Semecircle*) into 180 degrees, but if a *Quadrant* into 90.

The fourth and last part of this Instrument is a Scale divided into a certain number of equall parts, whose use is chiefly to finde Altitudes, and Profundities. The description and use of this Instrument is largely treated on by Master *Leonard Digs*, in his *Pantometria*, and therefore I am emboldned to passe it over with the more brevity.

CHVP. III.

A Description of the Circumferentor, *and the parts thereof.*

FOR portability, this Instrument exceedeth any other, and is usually made of wood, containing in lengh about eight inches, and in bredth four inches, and

in thickneſſe three quarters of an inch, the left ſide whereof is divided into divers equall parts, moſt fitly of twelve in an inch, to be uſed as the Scale of a Protractor, the Inſtrument it ſelfe being fitting to protract the plat on paper by help of the Needle, and the degrees of *Angles*, and length of lines taken in the field. About the middle of the upper ſide of this Inſtrument is turned a round hole, three inches, and a halfe Diameter, and about halfe an inch deep: in which is placed a *Card* divided commonly into 120 equall parts, & each part again into three, which makes 360 anſwerable to the degrees of the *Theodolite*; in which *Card* is alſo a *Diall* drawn to finde the hour and *Azimuth* of the Sun; over this *Card*, and within the *Box*, is hanged a Needle touched with a *Load-ſtone*, and covered over with a cleer Glaſſe, to preſerve it from winde and weather.

On the upper part of this Inſtrument is alſo deſcribed a *Table* of *Sines* divided anſwerable to the *Card* ſpecified before, that is to ſay, if the *Card* be divided but into 120 parts, the *Sines* muſt be ſo alſo; but if into 360, the *Sines* muſt be the abſolute degrees of the *Quadrant*: but in regard we intend onely to make uſe of the *Plain Table*, we will reject that *Table* of *Sines* in regard we have hereafter added a *Table* of *Artificiall Sines* to ſupply that defect more commodiouſly.

There

There is alſo belonging unto this Inſtrument wo *Sights*, the one double in length to the o-her, the longeſt containing about ſeven inches, eing placed and divided in all reſpects, as thoſe ereafter mentioned in the deſcription of the *Plain Table*. On the edge of the ſhorter *Sight*, toward he upper part thereof, is placed a ſmall *Wyer* repre-enting the *Center* of a ſuppoſed *Circle*, the *Semedi-meter* whereof is the *diſtance* from the *Wyer* to the dge of the Inſtrument underneath the ſame, which part is imaginarily divided into ſixty equall arts, and according to thoſe diviſions is the ight line of diviſions on the edge of the Inſtru-ent, divided and numbred by 5, 10, 15. from he perpendicular point to the end thereof: And lſo from the ſame point on the upper edge of the nſtrument is perfected the degrees of the *Qua-rant*, ſupplying the reſidue of thoſe which ould not be expreſſed on the long *Sight*, from 28 o 90 by tens.

There are alſo belonging unto theſe diviſions, little Ruler at the one end whereof is a little ole to put it upon the wyer on the edge of the horter *Sight*, at the other end of this Ruler is laced a ſmall *Sight*, directly over the fiduciall dge thereof; which edge is likewiſe divided ac-ording to thoſe diviſions on the edge of the In-rument. To this ſhort *Sight* is added a *Plummet* o ſeat the Inſtrument horizontall. Note,

Note, that this ſhort ruler and diviſions ſerv
for taking of Altitudes and Profundities, and fo
the reducing of hypothenuſall, to horizontall line

Chap. IV.

Of the Plain Table, *and the ſeverall parts, which it is compoſed, how it may be made gene rall, and ſupply the wants of the other two I ſtruments before mentioned.*

IF what generall uſe this *Plain Ta ble* is of, I ſhall make appear wh I come to the uſe and applicati thereof, to our preſent purpoſe, the interim give me leave to d ſcribe the ſeverall parts thereof, as I would adv (where I may) my Surveyour to haue it frame

The Inſtrument conſiſteth of ſeverall parts, a Firſt, The *Table* it ſelfe, being a *Parallellagra* containing in length about fourteen inche and a halfe, and in bredth eleven inches. This *Ta ble* is in three ſeverall Boards, which may be eaſil taken aſunder for eaſe and convenience in carri age. The ſecond part of which this Inſtrumen is compoſed, is a joynted frame, ſo contrived that it may be taken off, and put on the *Table* a pleaſure, and is to faſten a ſheet of paper upon th *Table*, when you are to deſcribe the plot of an field

field, or other incloſure by the *Table*. This frame may have upon it neer the inward edge, Scales of equall parts, on both ſides, for the exact and ſpeedy drawing of parallel lines upon the paper.

The third part of this Inſtrument is a *Ruler* or *Index* containing in length about ſixteen inches or more, it being full as long as from *Angle* to *Angle* of your *Table*, it ought to be about two inches in bredth, and one third part of an inch in thickneſſe: Unto this *Ruler* or *Index* belong two *Sights*, the one whereof is double in length to the other, the longer containing in length about twelve inches, the other halfe as much: on the top of this ſhorter *Sight*, is placed a braſſe pin, and alſo a thred and plummet to place your Inſtrument horizontall. Through the longer *Sight* muſt be made a flit, almoſt the whole length thereof. Theſe two *Sights* thus prepared, are to be perpendicularly erected upon the *Ruler* (by two *Morteſſes* made for that purpoſe) in ſuch ſort, that the wyer on the top of the ſhorter *Sight*, and the flit on the longer *Sight*, ſtand preciſely over the fiduciall edge of the *Ruler*. The ſpace or diſtance of theſe two *Sights* one from the other, is to be equall to the divided part of the longer *Sight* (which hereafter I may call the length thereof.) Upon the longer *Sight* is to be placed a Vane of braſſe, to be moved up and down at pleaſure,

through

through which a ſmall hole is to be made, anſwerable to the ſlit in the ſame *Sight*, and the edge of the *Vane*.

By theſe *Sights* thus placed on the *Ruler* there is projected the *Geometricall Square*, whoſe ſide is the divided part of the long *Sight* (or the diſtance between the two *Sights*.) In the middle of the long *Sight* (through the whole bredth thereof) there is drawn a line called the line of *Levell*, dividing the ſide of the projected *Square* into two equall parts: alſo the ſame ſide is on this *Sight* divided into a hundred equall parts, which are numbred upwards and downwards, from the line of *Levell*, by fives and tens to fifty, on either ſide, which diviſions are called the *Scale*.

There is alſo on the ſame *Sight* another ſort of *diviſion* repreſenting the *Hypothenuſall Lines* of the ſame *Square*, as they increaſed by *Unites*, and are likewiſe numbred upwards and downwards, from the line of *Levell*, from one to twelve, by 1 2 3. &c: ſomtimes ſignifying 101, 102, 103, &c. theſe *diviſions* ſhew how much any hypothenuſall or ſlope line drawn over the ſame *Square*, (that is, from the pins head to any ſuch *diviſion*) exceedeth the direct horizontall line, being the ſide of the ſame *Square*.

On this *Sight* there is a third ſort of *diviſions*, repreſenting the degrees of a *Quadrant* (or as many

many as the ſame *Sight* is capable to receive, which are about 25) numbred from the Line of *Levell* upward and downward by fives and tens to 25, which *diviſions* are called the *Quadrant*.

On the upper part of this *Ruler* may be placed the *Table* of *Sines*, before mentioned in the Deſcription of the *Circumferentor*.

Unto this Inſtrument alſo belong other neceſſary parts, as the *Socket*, the *Staffe*, the *Box*, and *Needle*.

According to this *Deſcription*, have *Plain Tables* uſually been made, but (as I ſaid before) that it may become an univerſall and abſolute Inſtrument, I would adviſe my Surveyour to have theſe additionall parts following.

1 Upon the frame (towards the outward edge thereof) I would have projected the 180 degrees of a *Semicircle*, from a *Center* noted in the Surface of the *Table*, and numbred from the left hand towards the right (when the *Center* is next to you) by fives and tens to 180, and back again the ſame way to 360. Theſe degrees thus inſerted is of excellent uſe in wet or ſtormy weather, when you cannot keep a ſheet of paper upon your *Table*, either in reſpect of rain or wind. And alſo it maketh

maketh the Surface, or upper part of your *Plain Table*, to be capable of all the uſes that the *Planiſphere* of the *Theodolite*, or the Card of the *Circumferentor* can performe.

2 Upon the *Index* or *Ruler* before ſpoken of, I would have (in ſtead of the *Sights* there deſcribed) two *Sights* with ſliding loops, both of one length, and double ſighted; the one having a ſlit below, and a thred above, and the other a ſlit above, and a thred below, ſerving to look backward and forward at pleaſure without turning about the Inſtrument, when the Needle is at quiet. How much expedition the back *Sights* will make, I ſhall leave to my Surveyour to finde by experience, for uſing theſe he ſhall need (in going about an incloſure) to plant his Inſtrument but at every ſecond *Angle*, and may look backward and forward at pleaſure without moving of the *Index*.

3 In ſtead of the *diviſions* of the *Sights* before deſcribed in the deſcription of the *Plain Table*, I would adviſe my Surveyour to have upon the *Index* of this *Plain Table* a *Quadrant*, whoſe limbe muſt be divided into 90 degrees, or equall parts: whereby all manner of *Altitudes*, and *Profundities*, are moſt exactly computed onely by *Addition*, and *Subſtraction*, without other *Arithmeticall* Calculation, or *Geometricall* Projection.

More-

Moreover, for the exact accompliſhment of this moſt abſolute Inſtrument there belongeth ſome other materiall parts, as a Box to contain a Card, and Needle (ſuch as is formerly deſcribed in the projection of the *Circumferentor*) covered over with a cleer glaſſe, and cloſe ſtopped with wax, to preſerve it from winde and weather.

This box may be ſo contrived, that it may have two *Morteſſes* made therein, to place the *Sines* of the *Plain Table*, and may have alſo the *Table* of *Sines* thereon, which is inſerted in the deſcription of the *Circumferentor*, and ſo will the *Plain Table* be as capable of all the uſes of the Inſtrument as of the *Theodolite*.

Alſo you muſt have a Socket of braſſe to be ſcrewed on the back ſide of the *Table*, to put in the head of your three legg'd Staffe; this Staffe ought to be joynted in the middle, ſo that it may be the more portable. This Staffe may be ſo fitted, as to be faſtened to the box, and needle, when it is uſed as a *Circumferentor*.

Note that this Inſtrument (when made as here is directed) is the moſt abſolute Inſtrument for a Surveyour to uſe.

CHAP.

Chap. V.

The making and division of a Decimall Chain.

For the better avoiding many inconveniences, I would advise my Surveyour to have his *Chain* made of a good round wyer, not to contain above two Statute *Poles*, or *Perches*, or three at the most, (which we will hereafter call an *Unite*, containeth in length 16 feet and a halfe, which is 198 inches, this quantity is first to be divided into ten equall parts called *Primes*, every of which contains in length 19 inches, and four fifth parts of an inch, and again, every of those *Primes* is to be subdivided into ten more equall parts, which we will call seconds, and so every of these seconds shall contain in length one inch and forty nine of fifty parts of an inch, and so is the whole *Perch*, *Unite*, or *Commencement*, divided into 100 equall parts, or Links, called Seconds.

The *Chain* being thus divided, at the end of every fifth pin, or fiftieth second, or link, which is the end of every half-pole, let a large curtain-ring be fastned, so shall you have in a whole chain, (if

(if but two Perches long) three of these rings, the middle-most being the *division* of the two Poles of which the whole Chain consisteth. Then at the end of every *Prime*, that is, at the end of ery tenth Second or Link, let a small curtain-ring be placed.

By these distinctions, the Chain is divided into these three terms: Units, Primes, and Seconds, whose Characters are these, o . . so that if you would expresse 26 Unites, four Primes, and five Seconds, they are thus to be written, 2645, by which you may perceive that those figures which have no prick over them, are Unites, or Intigers, and the first point, Primes, and the next, Seconds: and according to this rule three Unites, seven Primes, and two Seconds will stand thus 37 2

Besides these *Divisions* Mr. *Rathborne*, for his own use sowed at the end of every two Primes and a halfe (which is a quarter of a Pole) a small red cloth, and at every seven Primes and a halfe (being the three quarters of a Pole) the like of yellow, or other discernable colour, which if my Surveyour likewise do, he shall most speedily reckon the quantity of every Ring, remembring, that if it be the next Ring short of the red, it is two Primes, if the next over, three, if the next short of the yellow, seven Primes, if the next over, eight; if the next short of a great half-ring,

it

it is four, the next over, six: and lastly, if the next, short of the middle great Ring, it is nine, and if the next over, one.

But here is to be noted, that if you use this distinction by colours, you must work with one end of the Chain from you always.

This Chain thus divided, and marked, you have every whole Pole equall to ten Primes, or 100 Seconds, every three quarters of a Pole, equall to seven Primes and a halfe, or 75 Seconds, every halfe Pole equall to five Primes, or fifty Seconds: and lastly, every quarter of a Pole, equall to two Primes and a halfe, or 25 Seconds.

Here is to be noted, that in the ordinary use of this Chain, for measuring and platting, you may take notice onely of Units, and Primes, which is more exact, than in ordinary use: but in case of Separation or Division of Lands, or for the dimension of common Fields, into severall parts, you may make use of Seconds.

Some Observations in the use of your Chain, and the manner to account upon the same.

It is to be observed that when you are to measure any distance with your Chain (especially if it be not by a hedge side, but in the middle of a field which

which moſt commonly happeneth, when you work by the plain Table, and take your Station in the midſt of the field, you muſt meaſure directly in a ſtreight line (otherwiſe great errour may enſue) which that you may do with moſt convenience, you muſt provide certain little ſticks (as arrows or the like) that at the end of every chain you may ſtick one of them into the ground, and ſo you may (at every Chains end ſee whether they and your Inſtrument be in a ſtreight line or not, and if they be, you may be aſſured you have meaſured exactly, otherwiſe you may in time recall your ſelf and amend your errour.

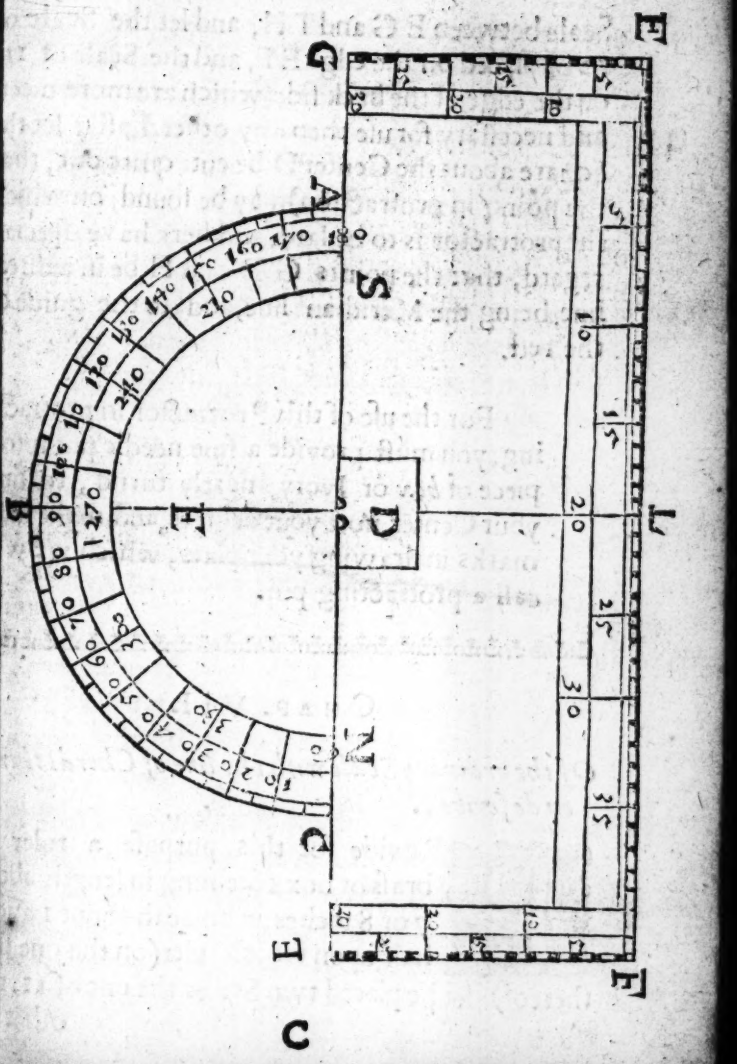
Theſe ſmall ſticks will ſtand you in excellent good ſtead for keeping of your account, for in meaſuring of a large diſtance you may eaſily miſtake a chain or two (if you be not very carefull) but the number of your ſticks, being taken up as you goe back from the place meaſured to your Inſtrument, will be a good remembrancer. The convenience of theſe will be beſt ſeen in practiſe.

CHAP.

Chap. VI.

A Description of the Protractor, *and the* Scale *thereof.*

A *Protractor* consisteth of two principall parts, *viz:* the *Scale*, and the *Semicircle*, it must be made of brasse, to contain in length from G to H five inches and a quarter, and in bredth from L to B somwhat more, then three quarters and a halfe, which place must be divided in the middle both ways, by the lines G H, and L B, cutting each other at right *Angles* in the point D, then upon the point D, as upon a *Center*, describe the *Semicircle* A B C, then divide the limb of this *Semicircle* into 180 equall parts or degrees, numbring them by fives and tens to 180, and back again to 360, as in the figure, the first number serving for the *East*-side and the latter for the *West*-side of the whole *Circle*. Then let the edges of the *Scale* as E G E F, and F H, be made very straight and smooth, and exactly parallel to the edges of the place of which the *Protractor* is made: then divide the parallel degrees at either end of the *Scale*


E
G
A
S
B
H
D
L
N
C
F
C

Scale between E G and T H, and let the Scale o
12 be placed on the edge E F, and the Scale of 1
on the edge of the back side, which are more mee
and necessary for use then any other. Lastly let th
Square about the Center D be cut quite out, th
the point (in protraction) may be found, on whic
the protractor is to be laid, and here have speci
regard, that the points G D and H be in a dire
line, being the Meridian line, and so the guide
the rest.

For the use of this Protractor in protrac
ing, you must provide a fine needle put into
piece of *box* or Ivory, neatly turnd, to fi
your Center, note your degrees, and make sm
marks in drawing your plats, which we w
call a protracting pin.

Chap. VII.

*Of the ordinary Scale with the line of Chords the
on described.*

PRovide for this purpose a ruler
bras or box, cōteining in length ab
7 or 8 inches, in breadth about 1 an
half, upon which ruler (on the one s
thereof) let be placed two Scales the one of 11.
other

of 12 in an Inch. On the ſame ſide let there be deſcribed a line of Chords, conteining in length 2 inches, or leſſe, of 60 or 90 degrees, whoſe Radius or 60 degrees thereof will be equall to the Semidiameter of the ſame Circle.

On the other ſide of this ruler may be placed after the order of theſe, divers other Scales, as of 16, 20, 24, &c. in an inch: ſo have you a neceſſary inſtrument for many purpoſes. To *uſe* with this Scale, you muſt provide a pair of neat compaſſes of braſs, with ſteel points, and alſo a neat pair of callem Compaſſes with ſcrews, to alter the points, as to draw with black lead, and any coloured ink, which will be of excellent uſe in decking and beautifiing of your plats after protraction.

CHAP. VIII.

The manner of ordering a field book, to be uſed with the Plain table, when you work by the degrees on the frame thereof, without drawing of Lines on the Table.

IT having been our buſineſſe hitherto to provide us of neceſſaries for our preſent purpoſe, let us not be deſtitute of this which is ſo neceſſary, for the making of which book, obſerve this direction; let it contein a quantity of paper more or leſſe (ſuppoſe half a quier or

there-about,) bound in a long Octavo, or a sem
folio, like an alphabeticall debt book, (which
best:) Let it be ruled towards the left Margine
every page with five lines, so shall you describe
Columns, the first serving for the degrees of obse
vation cut by the Index on the frame of your Ta
ble, and the second for parts of a Degree, for yo
are here to observe, that every part or degree on th
frame of of your Table is supposed to be sub-div
ded into 60 other parts called minutes, but it ma
be, if your Instrument be large and well divide
you may have every degree divided into three
quall parts, so shall every part contein 20 minute
the other 2 columns serve for the severall divisio
of your Chain, as the third for Unites, and th
fourth and last for Primes, or according to the a
customed use for degrees, Poles, and parts o
Pole.

CHA

CHAP. IX.

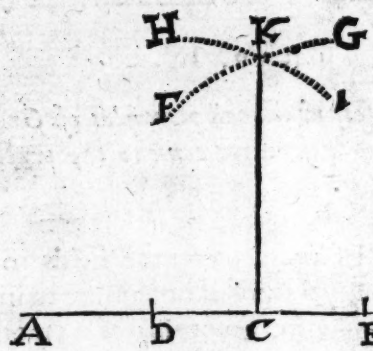
Conteining certein practicall principles of Geometry fit to be known before we come to the practise of Survey.

BEfore we enter the fields to Survey, I think it not amisse to instruct my Surveyor in the practise of some principles of Geometry, lest he should be ignorant thereof when need requires them: and make that seem hard and difficult which in it self so facile. First therefore I shall instruct him in these following propositions as being most necessary.

Prop 1

How to erect a perpendicular upon any point in a line assigned.

LEt A G be a line given and from the point C it is required to draw a line perpendicular to the line A B, first open the compasses to any small di-

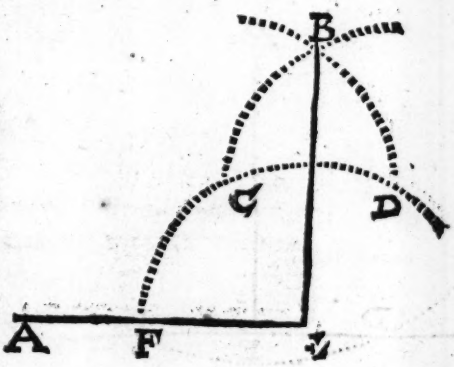


diſtance, and placing one foot in C make tw
marks in the line, *D* and *E*, then opening the com
paſſes to a greater diſtance, place one foot in *E*, a
with the other foot draw the arch *F G*, then (t
compaſſes keeping the ſame diſtance) place o
foot in *D*, and with the other draw the arch *H*
and from the point K, where theſe two lines Inte
ſect, draw a line to C, which line ſhall be perpe
dicular to the line A B, neither leaning on o
ſide or other, but directly ſtreight or perpendi
lar.

Prop. 2.

To erect a perpendicular on the end of a line.

LEt *A E* be a line given, and from the point *E* let it be required to erect the perpendicular E B.

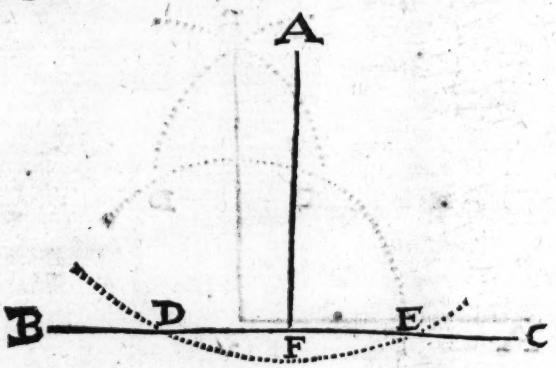


First open your Compaſſes to any diſtance, as o *E* F: then place one foot in *E*, and with the o-her deſcribe the Arch F C D, then place one foot n F, and with the other make the ſmall Arch C, nd removing the Compaſſes to C, draw the Arch D, then remove the Compaſſes to D, and draw he Arch C B, then draw the line E B which is he perpendicular required. Prop.

Prop. 3.

To let a perpendicular fall upon a line from a point assigned.

SUppoſe A be a point from whence it is required to draw a line perpendicular to the ground line B C.



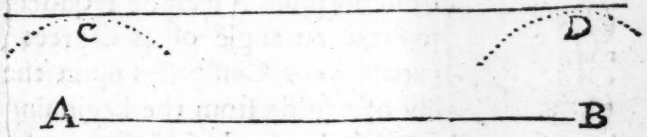
First open your Compaſſes to any Diſtance, ſo it be greater than A F, and place one foot in A, and with the other draw the Arch D E, then divide the diſtance D E into two equall parts at F, ſo ſhall the line A F be perpendicular to the line B C.

Prop.

Prop 4.

How to draw parallel lines.

PArallel Lines are such which being infinitly extended would never meet. Wherefore let A B be a line given, unto which, it is required to draw the line C D parallel, at the distance A C.



Having drawn the line A B, open the compasses to the distance A C, and placing one foot in A, describe the arch C, then removing your compasses to B, draw the arch D, then lay a ruler so that it may justly touch the top of the Arches C D, and the line so drawn shall be exactly parallel to A B.

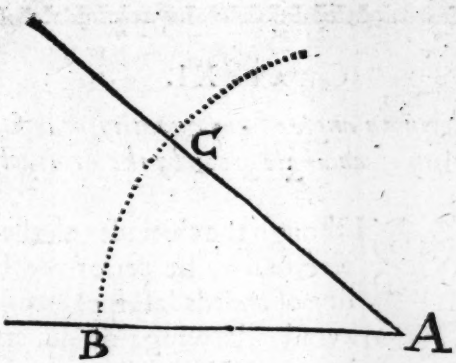
CHAP.

Chap. X.

Of the use of the Line of Chords placed on the ordinary Scale before described, and how to lay down an angle of any quantity required, or to find the quantity of an angle given.

DRaw a line at pleasure, as A B, and from the point A let it be required, to draw an angle of 40 degrees; extend your Compasses upon the line of chords from the beginning thereof to 60 degrees (which, as I said before in the description thereof, was equall to the Semidiameter of the circle from whence that chord was projected) with which distance, set one foot upon the point A, and with the other draw the pricked arch B C, then with your Compasses take 40 degrees (which is the quantity of the required angle) out of the line of chords, and set one foot thereof upon B, and extend the other to C, Lastly draw the line A C, and so the angle C A B shall contein 40 degrees.

But



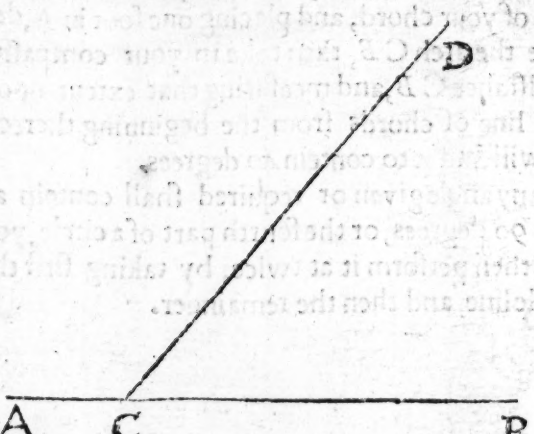
But ſuppoſe C A *B* were an angle given, and that it were required to find the quantity thereof, then as before, Open your compaſſes to 60 degrees of your chord, and placing one foot in A, deſcribe the arch C *B*, then take in your compaſſes the diſtance C *B*, and meaſuring that extent upon your line of chords from the beginning thereof, you will find it to contein 40 degrees.

If any angle given or required ſhall contein above 90 degrees, or the fourth part of a circle, you muſt then perform it at twice, by taking firſt the whole line, and then the remainder.

Chap. XI.

To lay down an angle of any quantity, or to find the quantity of an angle given by the Protractor.

ALthough the chief uſes of the Protractor may be performed by the line of chords laſt ſpoken of, yet to avoid drawing of ſuperfluous lines and arches, the protractor is far more convenient for our preſent purpoſe. Therefore ſuppoſe it were required to deſcribe an angle of 50 degrees by the Protractor, firſt



draw

draw a right line at length as *A B*, then on any part thereof, as on C, place the center of the Protractor, in which point ſet your protracting pin, and turn the protractor about, till the Meridian line of the Protractor, (noted in the deſcription thereof with G H) lie directly on this line A B, the Semicircle of the Protractor lying upwards, then by the Semicircle, at the diviſion of 50 degrees, mark the point D, and draw the line C D, ſo ſhall the angle B C D contein 50 degrees.

Again ſuppoſe *B* C D had been an angle given, and that it had been required to find the quantity thereof by the Protractor, firſt you muſt apply the center of the Protractor to the point C, and the Meredian line thereof directly on the line A *C* as before, then ſhall you find the point D to lie directly againſt 50 degrees in the protractor, and ſuch is the quantity of the angle required.

CHAP.

Chap. XII.

Of the congruity in use between the degrees described the frame of the plain Table, and the Circumferentor, and the manner how to find the quantity of an angle by either of them.

THese two Instruments in use differ little, save onely in this, that by the degrees described on the Plain Table, an angle is found by turning the Index about, till it lie directly against the Object to be measured, the needle still resting over the Meridian line of the Card, but by the Circumferentor an angle is found, by turning about the Instrument, till through the sights you discern the Object you would measure, then keeping the Instrument there, you are to measure your angle by the degrees, which the South end of the needle pointeth at upon the Card: by means hereof there is a diversity in the finding out of an Angle.

Here note that I now suppose the card of the Circumferentor, to be divided into 360 degrees, answerable to those on the frame of the plain Table, and not into 120, which is

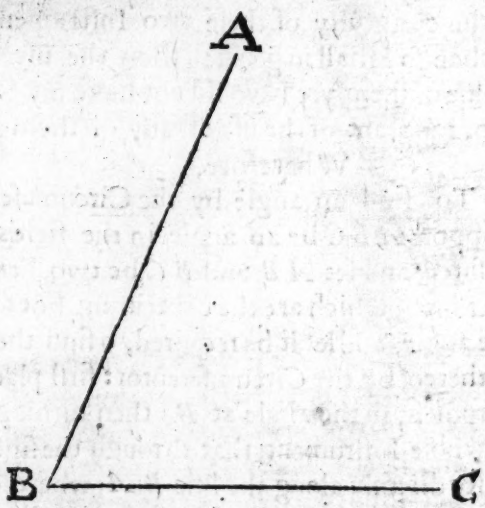
a

a third part thereof, (though for the Circumferentor, I approve of 120 for the better division in ſo ſmall an Inſtrument,) but in regard we intend to uſe onely the plain table, I wil not (at this time) alter my method for the benefit of this one concluſion, but onely ſhew the congruity of theſe two Inſtruments, and though I ſhall in generall ſhew the uſe but of one of them, yet I would not have my Surveyor ignorant of the uſe of any of them

Wherefore,

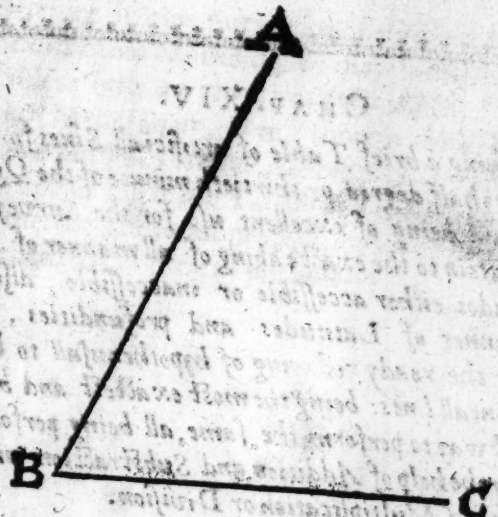
1 To find an angle by the Circum-ferentor. Suppoſe *A B C* be an angle in the fields to be meaſured, and let *A B* and *B C* be two hedges or other lines, which are the conteining ſides of the ſame angle, and let it be required, to find the quantity thereof by the *C*ircumferentor: firſt place your Inſtrument in the angle at *B*, then turning about the whole Inſtrument, that through the ſights you can ſee directly along the line *B A*, where obſerve what degree the South end of the needle cutteth when it ſtandeth ſtill, which let be 120 degrees, then direct your ſights towards *C*, and there making like obſervation, obſerve the degrees cut by the needle (when it again reſteth,) which let be 54; now you muſt ſubſtract 54 the leſſer term, from 120 the greater, and there will remain 66, the true quantity of the angle required: but had this remainder

mainder exceeded 180 degrees (which is a semi-circle or two right angles) then muſt you have deducted that remainder from 360, the degrees in the whole circle, and the remainder of that laſt deduction had been the quantity required.



2 *To perform the ſame by the degrees on the plain Table.*

In the former Diagram, place your Inſtrument at B, the Index ſtanding on the Diameter (which is a right line drawn quite along the Table from the beginning of the degrees, through the Center and



and so to the end of the degrees) then turn about the Instrument on the staffe, (the Index still resting on the *Diameter*) towards A, till your sight be parallel to the line *B A*, and there your Instrument being fixed, remove the Index (upon the center of the Table) directing your sight towards *C*, to be likewise parallel to *B C*, where observe what degree the edge of the Index cutteth, which will be 22, and that is the angle required without any substraction offering it self at the first view, and herein you cannot but perceive an excellent benefit and dispatch.

CHAP. XIV.

Conteining a brief Table of artificiall Sines for every half degree or thirtieth minute of the Quadrant being of excellent use for the Surveyour to attein to the exact taking of all manner of Altitudes either accessible or inaccessible, also all manner of Latitudes and profundities, and for the ready reducing of hypothennsall to horizontall lines: being the most exactest and briefest way to perform the same, all being performed by the help of Addition and Substraction without either Multiplication or Division.

NOt to meddle with the little Table of Naturall Sines spoken of in the description of the Circumferentor, I will here explaine and shew my SURVEYOUR, the use of a Table of Artificiall Sines and Logarithmes, by which he shall be able to perform more in the space of one hour, than by the other he is able to do in 6, and with far more exactnesse in regard of the brevity of the one and the largnesse of the other: (although these Tables themselves are too brief for any considerable calculations either in Astronomy or Geometry) there

therefore if my Surveyour desire exactnesse in these or other conclusions he may work by larger Tables: such as are already published by Mr. *Brigs*, Mr *Gunter*, & c. though these (for his present purpose) are exact enough. I intend therefore first to insert the Tables and then to shew the use thereof in severall propositions, and lastly apply them to our present purpose.

The Table of Sines.

D	m	Sine
1		8242
1	30	8418
2		8543
2	30	8639
3		8719
3	30	8785
4		8843
4	30	8894
5		8940
5	30	8981
6		9019
6	30	9053
7		9086
7	30	9116
8		9143
8	30	9170
9		9194
9	30	9217
10		9239
10	30	9260
11		9280
11	30	9299
12		9218
12	30	9335
13		9352
13	30	9368
14		9382
14	30	9398
15		9412
15	30	9427
16		9442
16	30	9453
17		9466
17	30	9478
18		9490
18	30	9501
19		9512
19	30	9523
20		9534
20	30	9544
21		9554
21	30	9564
22		9573
22	30	9583
23		9592
23	30	9600
24		9609
24	30	9618
25		9626
25	30	9634
26		9642
26	30	9649
27		9657
27	30	9664
28		9671
28	30	9678
29		9685
29	30	9692
30		9699
30	30	9705

The Table of Sines.

D	m	Sine
31		9712
31	30	9718
32		9724
32	30	9730
33		9736
33	30	9742
34		9747
34	30	9753
35		9758
35	30	9764
36		9769
36	30	9774
37		9779
37	30	9784
38		9789
38	30	9794
39		9798
39	30	9803
40		9808
40	30	9812
41		9816
41	30	9821
42		9825
42	30	9829
43		9834
43	30	9838
44		9842
44	30	9845
45		9849
45	30	9853

D	m	Sine
46		9857
46	30	9860
47		9864
47	30	9867
48		9871
48	30	9874
49		9878
49	30	9881
50		9884
50	30	9887
51		9890
51	30	9893
52		9896
52	30	9899
53		9902
53	30	9905
54		9908
54	30	9910
55		9913
55	30	9916
56		9918
56	30	9921
57		9923
57	30	9926
58		9928
58	30	9931
59		9933
59	30	9935
60		9937
60	30	9939

The Table of Sines.

D	m	Sine
61		9942
61	30	9944
62		9946
62	30	9948
63		9950
63	30	9952
64		9953
64	30	9955
65		9957
65	30	9959
66		9961
66	30	9962
67		9964
67	30	9965
68		9967
68	30	9968
69		9970
69	30	9971
70		9973
70	30	9974
71		9975
71	30	9977
72		9978
72	30	9979
73		9980
73	30	9982
74		9983
74	30	9984
75		9985
75	30	9986

D	m	Sine
76		9987
76	30	9988
77		9989
77	30	9989
78		9990
78	30	9991
79		9992
79	30	9992
80		9993
80	30	9994
81		9994
81	30	9995
82		9996
82	30	9996
83		9996
83	30	9997
84		9997
84	30	9998
85		9998
85	30	9998
86		9999
86	30	9999
87		9999
87	30	9999
88		9999
88	30	9999
89		9999
89	30	9999
90		10000

CHAP. XIV.

The explanation and use of the Table of Sines.

THe Table consisteth of two rowes or Columns, the first whereof sheweth the degrees and minutes in the Quadrant, having over the head thereof these two letters D M, standing for degrees and minutes, and the second Column sheweth the *Sine* answering thereunto, having the word *Sine* written over the head thereof: now the use hereof may appear by the following propositions.

Prop. I.

Any degree of the Quadrant being given to find the Sine *thereof.*

YOu must first find the degree in the first Column under the title *D M*, and in the next column towards the right hand you shall have the *Sine* answering thereunto.

Ex-

Example 1.

Let it be required to find the *Sine* of 12 degr. first you muſt ſeek 12 degrees in the firſt column under *D M*, and right againſt it you ſhall find 9318 which is the *Sine* of 12 degrees.

In like manner, the *Sine* of 25 degrees will be found to be 9626, and the Sine of 82 degrees will be found to be 9996.

Example 2.

Let it be required to find the *Sine* of 10 degrees 30 minutes.

This differeth nothing from the former, for firſt you muſt finde 10 30 (which is 10 degr. 30 min.) in the ſame column, under the title *D M*, and againſt it you ſhall find 9260 which is the *Sine* of 10 deg. 30 min.

Alſo the *Sine* of 28 degrees. 30 minutes will be found to be 9678, and the *Sine* of 86 degrees 30 minutes will be found to be 9999 and ſo of any of the reſt.

Prop. 2.

Any Sine being given to find the arch (or degree of the Quadrant) anſwering thereunto.

Example.

LEt this number 9239 be given, and let it be required to find the degree of the Quadrant anſwering thereunto, firſt I ſeek in the ſecond column among the *Sines* for 9239, and againſt it (on the left hand) I find 10 degrees, which is the arch anſwering thereunto.

In

In likemanner let it be required to find the arch answering to this *Sine* 9821, having found 9821, in the second column, against it you shall find 41 degr. 30 min. and that is the arch or degree answering thereunto.

But in case you have a number given which you cannnot find in the *Table*, you must then in stead thereof take the neereſt in the *Table*, As if your number given were 9350, if you look for this number in the *Table* it cannot be found but the neereſt thereunto is 9352, which you must take instead thereof.

Thus much concerning the generall use of this *Table* of *Sines*.

CHAP. XV.

The explanation of the Table *of* Logarithmes.

Logarithmes are numbers, so fitted to proportionall numbers, that themselves retein equall differences. This *Table* of *Logarithmes* conteins certein numbers increasing by a unite in a continuall proportion from to 120, so that any number under 120 being given

ven you may find the *Logarithme* thereof, or any *Logarithme* (whose absolute number exceedeth not 120) may be found by this *Table*, by the following propositions.

Chap. XVI.

Of the use of the Table *of* Logarithmes

Prop 1.

A number under 120 *being given to find the* Logarithme *thereof.*

Suppose the number given be 18 you must find 18 in the first column of the *Table*, (under the title Num. and against it in the second you shall find 1255, which is the *Logarithme* thereof.

Also, let it be required to find the *Logarithme* of 75. seek 75 in the first column, and against it in the second you shall find 1775 which is the *Logarithme* thereof.

N	Log
1	0000
2	0301
3	0477
4	0602
5	0698
6	0778
7	0845
8	0903
9	0954
10	1000
11	1041
12	1079
13	1113
14	1146
15	1176
16	1204
17	1230
18	1255
19	1278
20	1301
21	1322
22	1342
23	1361
24	1380
25	1397
26	1414
27	1431
28	1447
29	1462
30	1477

Nu	Log
31	1491
32	1505
33	9518
34	1531
35	1544
36	1556
37	1568
38	1580
39	1591
40	1602
41	1613
42	1623
43	1633
44	1643
45	1653
46	1663
47	1672
48	1681
49	1690
50	1699
51	1707
52	1716
53	1724
54	1732
55	1740
56	1748
57	1756
58	1763
59	1771
60	1778

N	Log
61	1785
62	1792
63	1799
64	1806
65	1812
66	1819
67	1826
68	1833
69	1839
70	1845
71	1851
72	1857
73	1863
74	1869
75	1875
76	1881
77	1886
78	1892
79	1897
80	1903
81	1908
82	1914
83	1919
84	1924
85	1929
86	1934
87	1939
88	1944
89	1949
90	1954

N	Log
91	1959
92	1964
93	1968
94	1973
95	1978
96	1982
97	1987
98	1991
99	1995
100	2000
101	2004
102	2008
103	2013
104	2017
105	2021
106	2025
107	2029
108	2033
109	2037
110	2041
111	2045
112	2049
113	2053
114	2056
115	2060
116	2064
117	2068
118	2072
119	2075
120	2079

Prop. 2.

A Logarithme being given to find the absolute number thereof.

LEt the *Logarithme* given be 1146, if you ſeek this number in the ſecond column of the *Table*, (under the title *Logar.*) you ſhall find againſt it (in the firſt column) 14 which is the abſolute number of that *Logarithme*.

But (as in the *Sines*) if you find not the abſolute *Logarithme* you look for in the *Table*, you muſt take the neereſt thereunto.

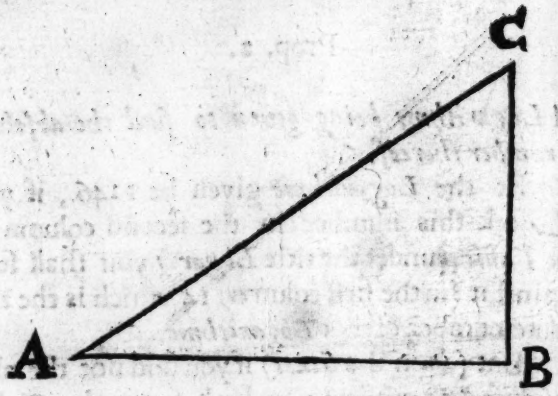
CHAP. XVII.

Of the joynt uſe of the Tables of Sines *and* Logar. *in the menſuration of the* ſides *and* angles *of right lined* Triangles.

FOr as much as the taking of altitudes and diſtances depends wholly upon the menſuration of right lined *Triangles*, I will firſt inſtruct my Surveyor in that doctrine, and firſt he muſt conſider that:

1 A *Triangle* is a figure comprehended of 3 ſides, and 3 *angles*, as is the figure A B C.

3 Eve-



2 Every two sides of a *Triangle* are called the sides of the *angle* comprehended by them, as the sides A B and A C are the sides of the *angle* C A B, *for you must note that every angle is noted with three letters, the middlemost whereof is the angular point.*

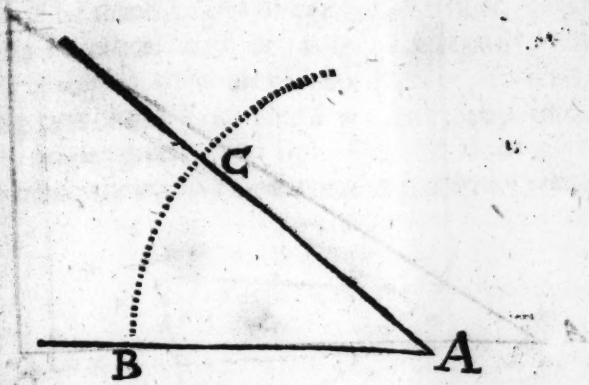
3 The measure of *angle* is the arch of a circle described on the angular point, as in the following *Triangle* the arch C B is the measure of the *angle* C A B.

4 A degree is the three hundred and sixtieth part of any circle,

5 A semi-circle is the half of a whole circle conteining 180 degrees.

6 A Quadrant is the fourth part of a circle conteining 90 degrees.

2 The



7 The complement of an *angle* is ſo much as the *angle* wanteth of 90 degrees, as ſuppoſe the *angle* C A B ſhould contein 40 degrees, the complement thereof would be 50 degrees, for if you take 40 from 90 there will remain 50.

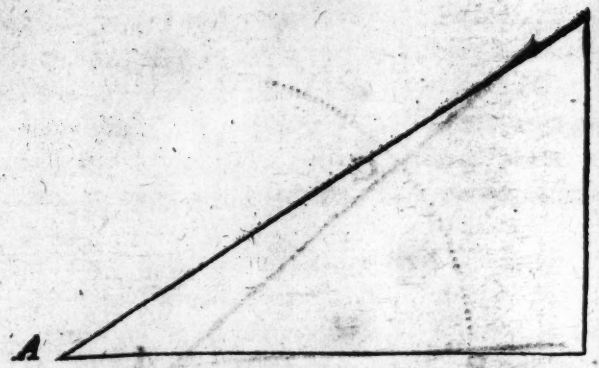
8 The complement of an *angle* to a ſemi-circle is ſo much as the ſaid *angle* wanteth of 180 deg.

9 An *angle* is either right, acute, or obtuſe,

10 A right *angle* is that whoſe meaſure is a Quadrant, as is the *angle* C B A.

11 An acute *angle* is leſſe than a right *angle*.

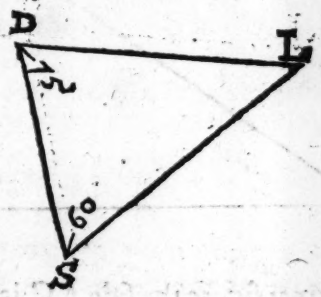
12 An obtuſe *angle* is more than a right *angle*.



13 A *Triangle* is either right *angled* or oblique *angled*.

14 A right *angled Triangle* is that which hath one right *angle*, as the *Triangle* A B C right angled at B.

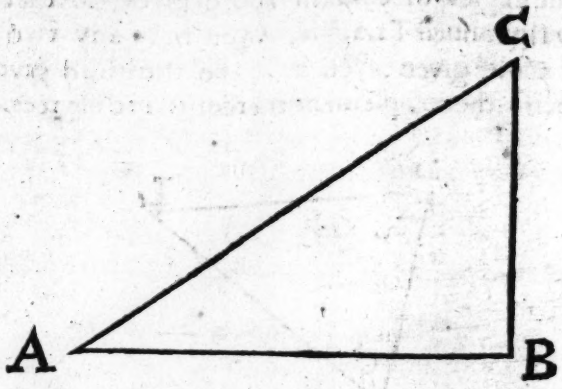
15 The three Angles of every right lined Triangle, whether acute or obtuſe, are equall to two right angles, or contein 180 degrees, ſo that in any right lined Triangle, if you have any two of the angles given, you have alſo the third given, it being the complement thereof to 180 degrees.



As in the Triangle *S D L*, ſuppoſe you had given the angle *S D L* 75 degrees, and the angle *D S L* 60 degrees, I ſay by conſequence you have likewiſe given the third angle *D L S* 45, it being the complement of the other two to 180 degrees: For the two given angles 75 and 60 being added together make 113, which being taken from 180, there remains 45, the quantity of the third angle.

16 In every right angled Triangle the ſide which lieth oppoſite to the right angle is called the Hypothenuſall, and of the other two, the one is called the perpendicular, and the other the baſe,

at pleaſure, but moſt commonly the ſhorteſt is called the perpendicular, and the longer the baſe.



As in the former figure the ſide A C is the Hypothenuſall, *A B* the baſe, and *C B* the perpendicular.

17 In every right angled Triangle, having one of the acute angles given, you have alſo the other given, it being the complement thereof to 90 degrees. As in the Triangle *A B C*: ſuppoſe the angle *C A B* were 40 degrees, then by conſequence the angle *A C B* muſt be 50 degrees.

18 In all plain Triangles the ſides are in proportion the one to the other, as the Sines of the angles oppoſite to thoſe ſides: As in the Triangle A B C. The Sine of the angle A C B, is in proportion to the ſide A B, as the *S*ine of the angle *C AB* is to the ſide CB, *& contra*. *A-*

Again in the Triangle *A* B C.

Suppoſe C B were a Tree, Steeple, or Tower, and that ſtanding at *A* with your quadrant you find the angle C *A* B to contein 40 degrees, (as is hereafter taught) then by conſequence the angle *A* C B is 50 degrees, and that you meaſure the diſtance *A* B and find it to contein 60 yards, you may find the ſide *C* B in this manner: for,

As the Sine of the angle ACB 50 degr. (which is)	9884
is to the Logar. of the ſide AB 60 yards, (which is)	1778
So is the Sine of the angle C A B 40 degrees	9800
the ſum of the ſecond and third number	11586
the firſt number ſubſtracted from the ſum	9884
to the Logar. of the ſide C B	1702

whoſe number anſwering to that Logarithme is 51 and that is the heigth of the ſide C B in yards.

A generall rule.

In all proportions wrought by Sines and Logarithmes, you muſt adde the ſecond and third numbers together, and from the ſumm of them you muſt ſubſtract the firſt number, and the remainder will anſwer your queſtion, as in the foregoing example you may perceive.

Another example.

Suppoſe (in the ſame Triangle,) it were required to find the hypothenuſall *A C* having the ſame things given as before, the proportion will be thus:

As the Sine of the angle ACB 50 degrees (which is) 9884
is to the *Logar.* of the side AB 60 yards (which is) 1778
So is the Sine of the angle ABC 90 degrees 10000
the sum of the second and third numbers 11778
the first number substracted from the sum 9884
To the *Logar.* of the side AC 1894

Whose number answering to that *Logarithme* is 78 and that is the length of the side AC in yards.

CHAP. XVIII.

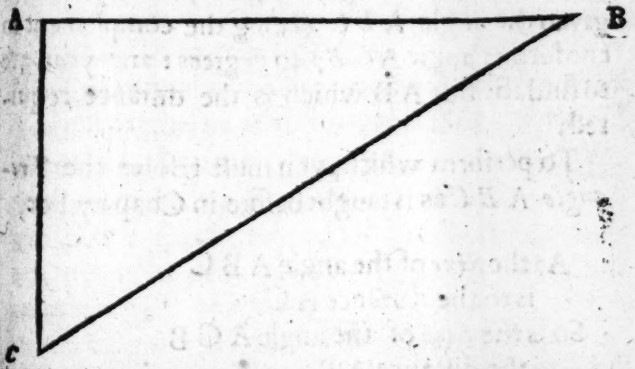
How to take an inaccessible distance at two stations, by the Plain Table: *and the* Tables *of* Sines *and* Logarithmes *before mentioned.*

NOw that my Surveyor is sufficiently skil'd in the use of his *Tables*, of *Sines* and *Logarithmes*, we will now shew him how he may apply them to his present purpose, in taking heights, depths, and distances, for by his *Plain Table*, with it's appurtenances, and his *Tables* of *Sines* and *Logarithmes*, he may with celerity and exactnesse measure the distance of any place or places far remote; also the Altitude of any Mountain, Hill, Tower, Steeple, or Sconce; whether accessible or in-accessible: and

and first how to take an inaccessible distan two stations.

Suppose you were standing at A, and that B were some notable mark, as a Tree, or the like, whose distance you would know from A your place of standing, but by reason of some opposition, as water or the like, you cannot come neer it.

First plant your Instrument at *A*, then laying the Index with the *Sights* upon the *Diameter* thereof, turn the whole Instrument about, till through the *Sights* you see the mark at *B*: then fasten the Instrument there, and turn the Index about, till it lie upon 90 degrees (which is a right



angle) then looking through the *Sights* again, let one set up some mark at C, whose distance *A C* let be 30 yards, (or any other number of equall

parts.) Then removing your Instrument to C laying the Index on the *Diameter* thereof, and turning the whole Instrument about till through the *Sights* you espie your first place of standing at *A*: which found, fasten the Instrument there, and move the Index about, till you espy your mark at *B*, observing what degrees the Index cutteth on the frame of the *Table*, which known, you may compute the distance *A B* in this manner: For by your two stations *A C* and your mark *B* you have made the right angled Triangle *A B C*, in which you have given the side *A C* (which is the distance of your two stations, 30 yards;) and you have given the angle *A C B* (observed by your Instrument at C) 50 degrees, and 3 you have given the angle A *B C* (being the complement to the former angle A *C B*) 40 degrees: and you are to find the side A B which is the distance required.

To perform which, you must resolve the *Triangle* A *B C* as is taught before in Chap 17. For,

As the *Sine* of the angle A B C
is to the distance A C
So is the *Sine* of the angle A C B
to the distance A B

So that if you adde the *Sine* of the angle A C B to the *Logarithme* of the side A C, and from the sum

ſum of them, ſubſtract the *Sine* of the angle A B C; the remainder ſhall be the *Logarithme* of the diſtance A B: as in example.

The *Sine* of the angle A C B is 9884, which added to the *Logarithme* of the diſtance A C 1477 the ſum of them is 11361, from whence if you ſubſtract the *Sine* of the angle A B C which is 9808 there will remain 1553 which is the *Logarithme* of the diſtance A B, which is almoſt 36 yards.

I have been more large upon this particular then I intended, (having ſufficiently inſiſted thereon before in the joynt uſe of the *Sines*, and *Logarithmes*,) but that my Surveyor may not be ignorant of theſe neceſſary concluſions: I have in this uſed all the perſpicuity I could imagine, ſo that in the ſubſequent Chapters, I may be the briefer, for if he underſtand this one aright, he will be capable of any of the other at the firſt view.

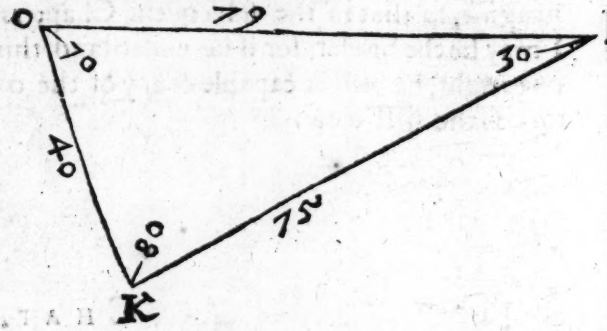
CHAP.

Chap. XIX.

To take an inaccessible distance at two Stations, not regarding whether the two Stations and distance required make a right angle.

LEt O and K be two stations, from either of which it is required to find the distance to L.

Having placed your Instrument at O the ruler lying upon the *Diameter* or no degrees, direct your *Sights* to L, and there stay your Instrument, then turn your index



about, till through your *Sights* you espy your second station, at K, noting the degrees cut by the Index

Index, which let be 70, then remove your Instrument to K, and there make observation again, by directing your *Sights* first to O, and then to L, and suppose the degrees cut at this second observation, were 80; so in the Triangle O L K have you two *angles* given, *viz.* L O K and O K L, and by consequence you have the third *angle* O L K 30 degrees (it being the complement of the other two to 180 degrees by the 15 prop. of Chap. 17.) and likewise you have given the distance O K (which you may measure with a Chain or otherwise,) 40 yards; and you are to find the distances O L, and K L. which you may perform according to the last.

For,

As the *Sine* of the *angle* O L K 30 degrees
is to the *Logarithme* of the distance O K 40 yards,
So is the *Sine* of the *angle* O K L 80 degrees
to the *Logarithme* of the distance O L.

Therefore if to the *Logarithme* of 40, you adde the *Sine* of 80, and from the sum of them subtract the *Sine* of 30, you shall have remaining the *Logarithme* of the distance O L.

See the following work.

The

The *Sine* of O L K 30 degrees	9699
The *Logarithme* of the distance OK 40 yards	1602
The *Sine* of O K L 80 degrees	9993
The sum of the second and third numbers	11595
The *Sine* of 30 degrees substracted from the first *Sine*.	9699
The *Logarithme* of the distance O L	1896

the number answering thereunto is 79 and so many yards is the distance O L.

By the same rule, you may likewise find the distance K L, For,

As the *Sine* of the *angle* O L K 30 degrees
is to the *Logarithme* of the distance O K 40 yards,
So is the *Sine* of the *angle* L O K 70 degrees
to the *Logarithme* of the distance *K L*.

Which by adding the *Logarithm* of 40 (the distance O K) to the *Sine* of 70 (the angle L O K) and from the sum of them both substract the *Sine* of 30 (the *angle* O L K) you shall find the *Logarithme* of the remainder to be 1876, the number answering whereunto is 75, and so many yards is the distance K L.

A generall rule

In all Synicall proportions (that is in all such propositions where you use *Sines*) observe this generall rule, that in all cases whatsoever, you must

must adde the ſecond and third terms (or numbers) together, and from the ſum of them both you muſt ſubſtract the firſt term, and the remainder ſhall be the third term, and anſwer to your queſtion.

CHAP. XX.

How to protract or lay down a diſtance thus taken: upon paper or paſtboard by help of your Protractor or line of Chords.

SUppoſe it were required to draw upon paper or paſtbord the Symetry or proportion of the diſtance laſt taken.

Firſt draw a line at length as O *L*, then upon one end thereof, as at O, place the center of your protractor, and lay the line G H of the protractor directly upon the line O L, then becauſe the *angle* L O K is 70 degrees, againſt 70 degrees of your Protractor make a mark upon your paper with your protracting pin (as is taught in Chap. 11) and draw the line O K, upon which line from *O* to *K* ſet of 40 equall parts from any of your *Scales* (repreſenting 40 yards the diſtance of your two ſtations:) then remove your protractor

to

to *K*, placing the line G H of the Protractor directly upon the line *O K* on your paper, and because the *angle O K L* was 80 degreees, you must make a mark upon your paper just against 40 degrees of your Protractor, and draw the line *K L*, which will cut the line *O L* in *L*, and then if you measure the length of the lines *O L* and *K L* by the same *Scale* from whence you took off 40 for the line *O K*, you shall find the line *O L* to contein 79, and the line *K L* to contein 75 exactly agreeing with the Calculation in the last Chapter.

And here my Surveyour cannot but be abundantly satisfied, to see the congruity of his Operations, considering what affinity and harmony there is between Arithmeticall Calculation and Geometricall projection.

CHAP.

CHAP. XXI

How to take an accessible altitude by the Quadrant on the Index *of your Plain Table.*

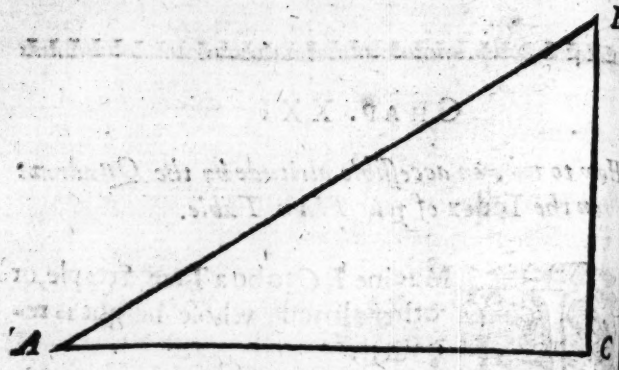
IMagine *B C* to be a Tree, Steeple, or other altitude whose height is required.

Place your Instrument exactly levell at *A*, the Quadrant being set upon the *Index* of your Table, then lift your Quadrant up or down till through the *Sights* thereof, you espy the very top of the building, at B, and observe what degrees of the Quadrant are cut by the fiduciall line, for those degrees are equall to the *angle* B A C (which suppose to be 30,) then by consequence A B C is 60, the complement of the other to 90, likewise measure the distance from A, the place of your standing, to C, the base or foot of the thing to be measured, which suppose to be 70 foot, or yards, which known you have given in the *Triangle* A B C.

1 The *angle* B A C observed your Instrument at A 30 degrees.

2 You have the *angle* A B C the complement of the former to 90 degrees, *viz.*, 60 degrees.

3 And



3 And lastly you have given the distance A C, the distance from your station to the base of the altitude to be measured 70 foot.

And you are to find the side B C the altitude required.

Which to perform say thus,

As the *Sine* of the *angle* A B C 60 degrees
is to the *Log.* of the distance A C,
So is the *Sine* of the *angle* B A C
to the *Log.* of the altitude *B C.*

Which according to the former work of this Nature will be found to be about 40 foot and a half.

CHAP.

Chap. XXII.

How to protract or lay the former observation on paper by help of the Protractor.

HAving drawn a line as A C, place the Center of your Protractor upon A, and the Line G H of your Protractor on the line A C, then with your protracting pin make a marke upon your paper just by the side of your Protractor at 30 degrees, and from A through that point draw the line A *B*, then because the Distance A C was 70 foot, take 70 out of any of your lines of equall parts, and set that distance from A to C, and from the point C erect the Perpendicular *C B*, which shall contein 40 foot and a half as before.

Chap.

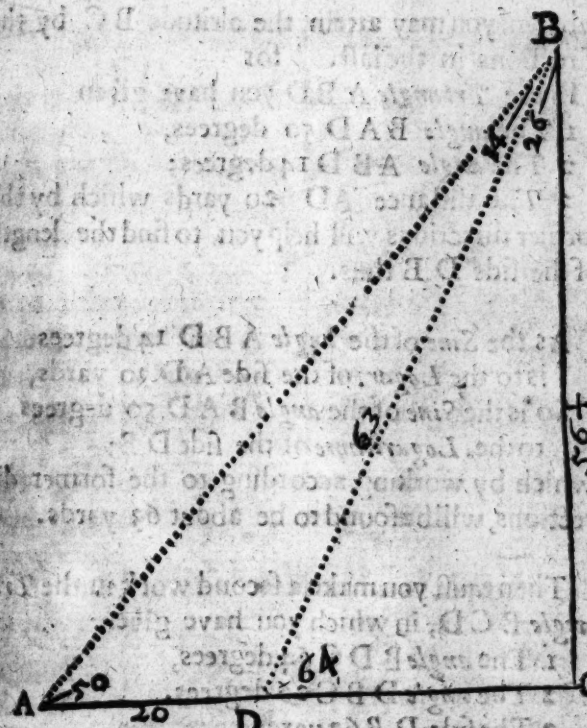
CHAP. XXIII.

How to take an inaccessible altitude at two stations.

MAny Conclusions of this nature may be performed with much celerity and exactneſſe, but for as much as this and the following are the moſt neceſſary, I ſhall inſtruct my Surveyor in them.

Let *B C* be the altitude of ſome building or the like, and let it be required to find the height thereof.

Having planted your Inſtrument at *A*, direct the *Sights* of your Quadrant to B, and note the degrees cut in the Quadrant by the fiduciall edge which let be 50 degrees, and theſe degrees is the quantity of the *angle B A C*; then becauſe you cannot approach to the baſe of the building at C, meaſure from *A* towards *C* ſo far as you can, which let be to D, and ſuppoſe that diſtance *A D* to be 20 yards, then remove your Inſtrument to D, and there again obſerve as you did at *A*, finding the *angle* to be 64 degrees, which known, you may conſider, that the *angle* B D C obſerved at the



the second station being 64 degrees, the Complement thereof DB C must be 26 degrees, and likewise knowing the *angle B A C* to be 50 degrees, the *angle A B C* must be 40 degrees, from which *angle* B A C 40 degrees, you must substract the *angle* DBC 26 degrees, and there will remain the *angle* A B D 14 degrees, by the knowledge

whereof you may attein the altitude B C by the directions in the laſt. for

In the *Triangle* A B D you have given

1 The *angle* B A D 50 degrees,

2 The *angle* A B D 14 degrees;

3 The diſtance A D 20 yards which by the former directions will help you to find the length of the ſide D B thus.

As the *Sine* of the *angle* A B D 14 degrees
is to the *Logar.* of the ſide A D 20 yards,
So is the *Sine* of the *angle* B A D 50 degrees
to the *Logarithme* of the ſide D B;

which by working according to the former directions, will be found to be about 63 yards.

Then muſt you make a ſecond work in the *Triangle* B C D, in which you have given:

1 The *angle* B D C 64 degrees,

2 The *angle* D B C 26 degrees.

3 The ſide *D B* 63 yards.

And you are to find the ſide B C the altitude required, wherefore ſay again:

As

As the *Radius* or the *Sine* of 90 degrees (which is 1000)
is to the *Logar.* of the side D B 63 yards,
So is the *Sine* of the *angle* B D C 64 degrees
to the *Logarithme* of the altitude *B C*.
which according to the former doctrine will be found to be 56 yards and a half.

Chap. XXIV.

How to perform the work of the last Chapter by protraction.

Questions of this nature may many times be proposed, when a man may not be provided of all necessaries for the purpose; suppose therefore you were destitute of your *Tables*, of *Sines*, and *Logarithmes*, and had nothing to help your self withall but your Protractor, having therefore noted in a book, or otherwise, that the degrees cut at your first station at A were 50, and the degrees cut at the second station at D were 64, and that your stationary distance A D was 20 yards, you may immediately proceed to protraction.

First draw a line as A C, in which line let A repre-

preſent your firſt ſtation, whereon lay the center of your Protractor, and make the *angle* B A C to contein 50 degrees, (as hath been ſeverall times before ſhewn) and draw the line *A B*. Then upon the line A C ſet off the diſtance of your two ſtations 20 yards, which let be the diſtance A D, then bring your Protractor to *D* (which repreſents your ſecond ſtation) and placing the center of your Protractor therein, ſet off an *angle* of 64 degrees, and draw the line D B, then where theſe two lines A B and D B interſect or meet, which is in the point B, from that point let fall the perpendicular B C (as is before taught,) the length whereof being meaſured upon the ſame *Scale*, from whence you took the diſtance A D, will give you 56 and a half, and that is the altitude required.

CHAP.

Chap. XXV.

How to take the distances of severall places one from another, as also the distance of any of them from your place of standing, it being of excellent use to draw a plat of the most considerable marks, or bounds of a Town, Manner, or the like.

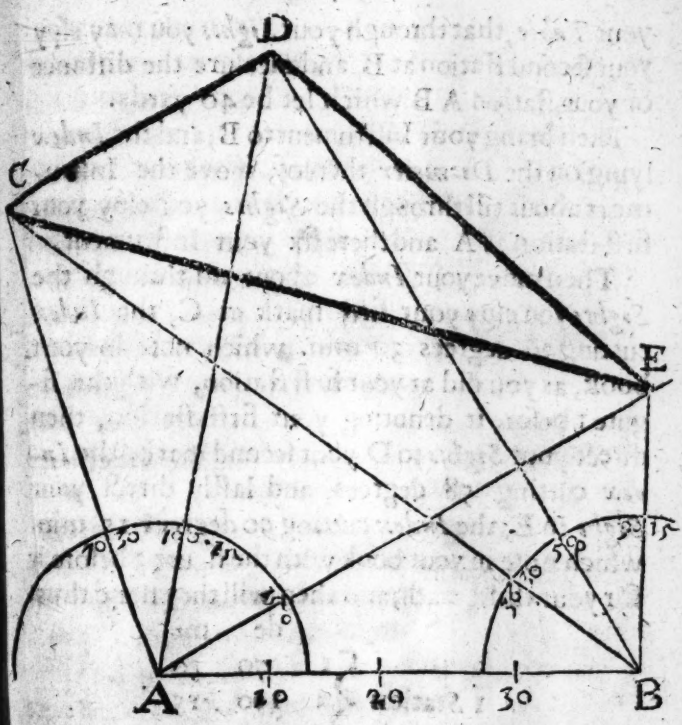
REpair to some place or other, from whence you may discern all those places whose distances you require at which place plant your Instrument, exactly levell, then move your *Index* about till through the *Sights* you espy your first mark, and then observe what degrees your *Index* cutteth on the frame of the *Table*, which degrees note down in a book, then turn your *Index* to your second mark and there note the degrees cut as before, and set them down: then direct your *Sights* to your third mark, and note them down as before, and so if there be more or lesse, till you have gone over them all.

Then for your second observation make choise of some other convenient place, from whence you may discern all the marks as before, which stationary distance let be as large as your ground with

convenience will permit, and ſo ſcituated that the *Index* lying on the *Diameter* of your *Table* at your firſt ſtation, through the *Sights* thereof you may perceive your ſecond ſtation, and likewiſe at the ſecond you may diſcern your firſt, ſo that in both ſtations the *Diameter* of the *Table* may be in a right line. At which ſecond ſtation you muſt make obſervation in all reſpects as before, by noting your degrees cut, and ſetting them down in a book by themſelves, ſetting a diſtinction between your firſt and ſecond ſtation, as alſo figures to your ſeverall marks, as 1 2 3 4 5 &c. at both ſtations: ſo that you may not miſtake when you come to protraction.

Let A B C be three ſeverall marks in the fields, or other notable marks, as Churches, Town-Hals or the like, and let it be required to find the diſtance of either of them from one another, as alſo the diſtance of any of them from A or B.

Make choiſe of your firſt ſtation at A, where placing your Inſtrument, direct your *Sights* to your firſt mark at C, and ſuppoſe the *Index* cuts 70 degrees, 30 min. which 70 degrees 30 min. muſt be noted in a book, as you ſee here following with the figure 1 before it ſignifying your firſt mark, then direct your *Sights* to D your ſecond mark, and let the degrees cut be 100 deg. 15 min. which muſt be likewiſe noted in your book, as before



fore with the figure 2 before it signifying your second mark, then turn your *Index* about, till through the *Sights* you espy your third mark at E, the *Index* cutting 150 degrees, which you must note down in your Book, with the figure 3 before it signifying your third mark.

This done bring your *Index* to the *Diameter* of your

your *Table*, that through your *Sights* you may espy your second station at B, and measure the distance of your station A B which let be 40 yards.

Then bring your Instrument to B, and the *Index* lying on the *Diameter* thereof, move the Instrument about till through the *Sights* you espy your first station at A, and there fix your Instrument.

Then move your *Index* about till through the *Sights* you espy your first mark at C, the *Index* cutting 36 degrees 30 min. which note in your book, as you did at your first station, with the figure 1 before it denoting your first station, then direct your *Sights* to D your second mark, the *Index* cutting 58 degrees, and lastly direct your *Sight* to E, the *Index* cutting 90 degrees 15 min. which note in your book with the figure 3 before it for your third mark, and then will they stand thus.

		de	mi
1 Station	1	70	30
	2	100	15
	3	150	00

Your Stationary distance 40 yards.

		de	mi
2 Station	1	36	30
	2	58	00
	3	90	15

By

By help of this table of your obſervations you may at any time protract the ſame on paper or otherwiſe, and then making a Scale of equall parts, anſwerable to the parts of your ſtationary diſtance, you may with your Compaſſes meaſure the diſtance of any of theſe marks one from another or from either of your ſtations, the manner of protracting whereof is ſhew'd in the next Chapter.

CHAP. XXVI

How to protract the former obſervations upon paper, and to make a ſcale to meaſure any of the diſtances.

DRaw a line at length as A B, let the two ends whereof A and B repreſent your two ſtations, then upon A your firſt ſtation, lay the center of your Protractor with the meridian line thereof (which is noted with G H) directly upon the line A B, then lay the *Table* of obſervations before you, and perceiving thereby that at your firſt obſervation your *Index* cut 50 degrees 30 min. you muſt with your protracting pin, make a mark againſt 70 degrees 30 min. of your Protractor, then again ſeeing that at your ſecond ob-

observation the *Index* cut 100 degrees 15 min. therefore with your protracting pin you must make a mark on your paper against 100 degrees 15 min. of your Protractor. And thirdly, seeing that at your third observation your *Index* cut 150 degrees, you must there likewise make a mark, and through these marks from A you must draw the streight lines A C, A D, A E.

Then remove your Protractor to B which signifies your second station, laying the meridian line thereof upon the line A B, and note the *angles* of your observations made at your second station in all respects, as you did those of your first station:

As first.

At the first observation of your second station the *Index* cut 36 degrees 30 min. therefore with your protracting pin make a mark upon the paper against 36 degrees 30 min. and the degrees cut at your second observation were 58 degrees, therefore make a mark against 58 degrees of your Protractor, and lastly the degrees cut at your third observation were 98 degrees 15 min. against which likewise make a mark, and then through these severall points from the point B draw streight lines till they intersect those before drawn from A, which will be in these three points C, D, and E, which three points bear a just proportion with the three marks which you observed in the fields.

Now

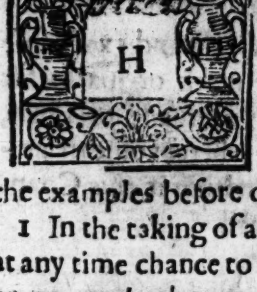
Now to to find the distance from A to any of these marks, you may divide a line into any number of equall parts, (as is before shewed) so that the distance from A to B may contein 40 of them, and by taking in your Compasses the distance between A and D, or A and C, or from D to C, or from B to C, or the length of any line in the whole plat, and apply it to your *Scale* so made, it shal exactly shew you the true distance or length of any line which is answerable to the like marks taken in the fields.

And thus may you with speed and exactnesse attein the true distance of any mark or marks far remote without approaching neer any of them, and thus in overgrown land, where you can neither go about it, nor measure within it, this Chap. will stand you in excellent stead.

CHAP.

Chap. XXVII.

Of some general observations to be observed in the mensuration of heights, depths, and distances before shewn, as also in taking the plats of inclosures. &c.



Having shewn you the manner of taking all sorts of heights, and distances, I shall now lay down some rules by which you may remedy many inconveniences that may oft-times arise, contrary to the examples before delivered. As

1 In the taking of any distance or altitude, if you at any time chance to meet with an obtuse *angle*, or an *angle* that exceedeth 90 degrees, (seeing the *Table* of *Sines* extendeth but to 90 degrees,) you must therefore in such a case deduct the excess of the *angle* above 90 degrees, out of 90 degrees, and of that remainder seek the *Sine* in the table, which will perform your work as well if you had the absolute *Sine* of the whole *angle*.

As if the *angle* whose *Sine* is required were is 132 degrees, the excess wherof above 90 degrees 42, which being deducted out of 90, the remainder is

is 48 degrees, the *Sine* whereof is answerable to the *Sine* of 132.

Or you may perform the same more briefly thus, For, If you substract your obtuse *angle* from 180 degrees, the remainder shall be the arch, whose *Sine* shall be answerable to the *Sine* of the obtuse *angle* given. example.

Let the arch given be the same as before, 132 degrees, this number being substracted from 180 degrees, the remainder will be 48 degrees, the *Sine* whereof shall exactly answer to the *Sine* of 132 degrees.

2 In taking of distances, the *Sine* of the *angle* opposite to your stationary distance must be your first term, your stationary distance must be your second, and the *Sine* of the *angle* opposite to the side required must be your third term.

3 Remember always in taking of inaccessible heighths and distances, as also in the platting of unpossible grounds, that you take your stationary distance as large as may be.

4 In regard the *Tables* of *Sines* and *Logar.* before mentioned are very brief and concise, I would advise my Surveyor to make use of those of Mr. *Gunter*, Mr. *Manwood*, *&c.* which are large and of exceellnt use both Geometricall and Astronomicall.

5 If at any time you be required to take the altitude

titude of a Tree, or Caſtle ſtanding on a Hill, of the like, you muſt perform it at two operations, firſt, by taking of the altitude of the Tree and Hill together, and ſecondly, by taking of the Hill alone, then ſubſtracting the height of the Hill from the whole height, you may conclude the remainder to be the height of the Tree.

6 In the taking of all manner of altitudes whether acceſſible or inacceſſible, you muſt adde to the height found the height of your Inſtrument from the ground.

CHAP. XXVIII.

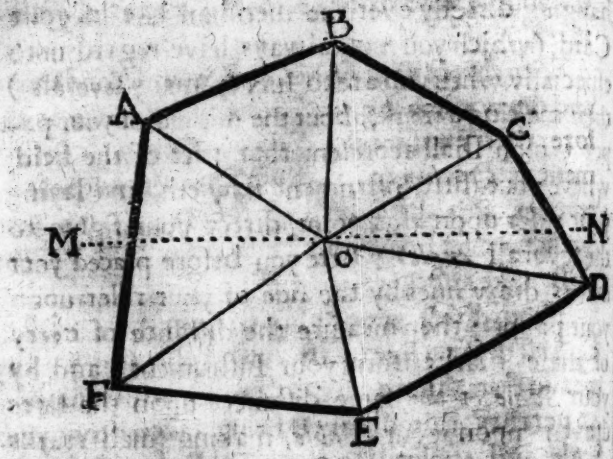
How to take the plot of a field (upon your Plain Table) in one ſtation taken in any part of the ſame field, from whence all the angles *of the field may be perceived.*

GOe round about the field, placing marks at every *angle* of the ſame, then make choiſe of ſome convenient place, about the middle thereof, from whence you may behold all your marks and there place your Inſtrument with a ſheet of paper, ſtretch thereon the needle hanging

hanging directly over the meridian line in your Card, (which you must always have regard unto especially when you are to survey many severals) then making a mark, about the middle of your paper which shall represent that part of the field, where your first Instrument standeth, and laying your ruler upon this point, direct your sights to the severall *angles* where you before placed your marks, draw lines by the side of your ruler upon your paper; then measure the distance of every of these marks from your Instrument, and by your *Scale* set the same distances upon the lines drawn upon your *Table*, making small marks with the points of your Compasses or blacklead at the end of every one of them; then lines being drawn by these points from one to another, you shall have upon your *Table* the exact plot of the field, all the sides and *angles* upon your *Table* being answerable to those in the field.

Suppose you were to take the plot of the field A B C D E F. Having placed marks in the severall *angles* thereof, as at A B C D E and F, make choise of some convenient place about the middle of the same field, from whence you may behold all your marks before placed in the severall *angles*, and there place your Instrument, which place let be O, then turn your Instrument about, till the needle hang directly over the meridian line of the

Card



Card noted at the ſouth end with a croſſe, and a
the north end with a flower deluce, which line i
repreſented in the following figure with M N.

Your Inſtrument being thus placed, with a ſhe
of paper thereupon, make a mark with black lea
or otherwiſe upon the paper, which mark ſha
repreſent upon your paper the place of your ſtand
ing in the field, then applying your *Index* to th
point, direct your ſight to your firſt mark at A
and the *Index* reſting there, draw a line by th
ſide there, then meaſure the diſtance from O th
place of your Inſtrument, to A the mark, whic
ſuppoſe to be 40 perches, then take 40 perch
from one of your *Scales*, and apply that diſtan

on your Table from O to A, and at A make a mark.

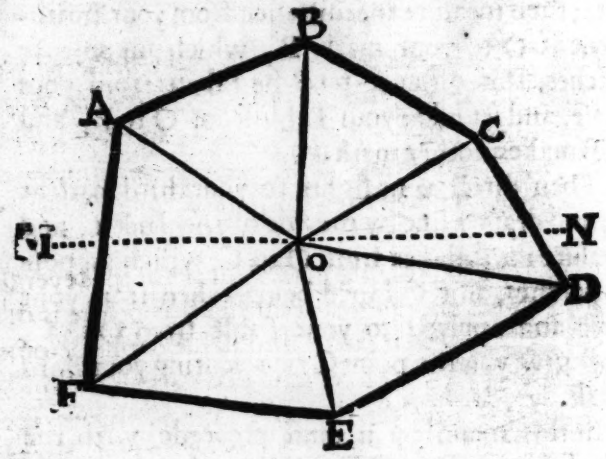
Then direct your ſights to B your ſecond mark, and draw a line by the ſide of your Index as before; then meaſure the diſtance from your Inſtrument at O to your mark B, which ſuppoſe 45 perches, this diſtance muſt be taken from your Scale, and ſet upon your Table from O to B, and at B make another mark.

Then direct your ſights to your third mark at C, and draw a line by the ſide of the Index, and meaſure the diſtance from O to C, which ſuppoſe 42 perches, this diſtance being taken from your Scale and applyed to your Table from O to C, ſhall give you the point C repreſenting your third mark.

In this manner you muſt proceede with the reſt of the marks at D E and F, and more, if the field had conſiſted of more angles.

Laſtly, when you have (according to the former directions) found all the marks A B C D E and F, upon your Table, you muſt draw lines from one mark to another till you conclude where you began. As ſuppoſe you began at A, and then to B and C, and ſo proceed round about the field till you come to A again: then draw a line from A your firſt mark to B your ſecond mark, and a line from B your ſecond mark, to C your third mark,

and from C your third mark, to D your fourth mark and likewise from D to E, from E to F, and from F to A where you first began. Then will



the lines AB, BC, CD, DE, EF, and FA, be the exact figure of the field, the sides and angles of the said figure bearing an exact proportion to those in the field, and the pricked line M N, in this and the following figures, representeth the Meridian line.

CHAP.

CHAP. XXIX.

How to take the plot of a Field by helpe of the degrees on the frame of your Plain-Table, when by reason of winde or rain you cannot keepe a sheet of paper upon your Table, and by measuring as in the last Chapter.

HAving placed marks at the severall angles of the field, as before is directed, and made choise of some convenient place about the middle thereof, from whence you may see all your former marks, place there your Instrument, the Needle hanging directly over the Meridian line.

This done, direct your sights to your first mark at A, noting the degrees cut by the Index on the frame of the Table, which suppose 40 degrees 15 minutes, these 40 degrees 15 minutes must be noted down in your field-book in the first and second columnes thereof; then measure the distance from O the place of your Instrument, to A your first mark, which let contain 40 perches, these 40 perches must be placed in the third columne of

your field-book, as hath been directed in the description thereof.

Then direct your sights to B your second mark, and note the degrees cut by the Index, which let be 88 degrees, and the distance O B 45 perches, the 88 degrees must be noted in the first columne of your field-book, and the 45 perches in the third Columne.

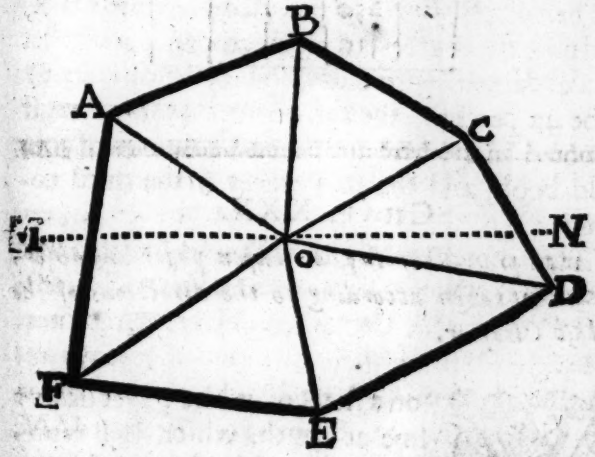
Then direct your sights to C your third mark, and note the degrees cut by the Index, which let be 130 degrees 45 minutes, and let the distance O C be 42 perches; the 130 degrees 45 min. must be noted in the first and second columns of your field-book, and the 42 Perches in the third columne.

Then direct your sights to D your fourth mark, and note the degrees cut by the Index on the frame of the Table, which let be 200 degrees 30 minutes. [*And here you must note, in the using of the degrees on the frame of your Table; that after you have passed* 180 *degrees, which is the line* MN, *(representing also the Meridian line,) you must then count the degrees backward, according as they are numbred on the frame of the Table from* 190 *to* 360:] then measure the distance O D, which let be 60 perches 4 primes; these 200 degrees 30 minutes must be noted in the first and second columns of your Field-book, and the 60 perches

4 primes

4 primes, in the third and fourth columns thereof.

Then direct your sights to E your fifth mark, the index cutting 250 degrees, and the distance O E being 39 perches, these must be noted in your booke as before, the 250 degrees in the first columne, and the 39 perches in the third.



Lastly, direct your sights to F your last mark, the Index cutting 310 degrees, and the distance O F being 50 perches, these must be noted down in your Field-book in all respects as the former, *viz.* the 310 degrees in the first columne, and the 50 perches in the third. And then will your notes

collected in your Field-book ſtand as in the following Table.

	deg	mi	pe	pri
A	40	15	40	0
B	88		45	0
C	130	45	42	0
D	200	30	60	4
E	250		39	0
F	310		50	0

CHAP. XXX.

How to protract or lay down upon paper any obſervations taken according to the directions of the laſt Chapter.

UPon a ſheet of white paper draw a line at length, which ſhall repreſent the line *M N* in the foregoing Figure; then make choiſe of ſome point or other in that line, to repreſent your ſtation or place of ſtanding in the Field, upon which point place the center of your Protractor, ſo that the line N S of your Protractor may lie directly upon the line *M N*

M N: Then laying your Field-book before you and ſeeing that at your firſt obſervation noted with *A* the Index cut 40 degrees 15 minutes, you muſt therefore againſt 40 degrees 15 min. of your Protractor make a mark upon your paper, which mark let be repreſented by the letter *A*.

2 Seeing the degrees cut at your ſecond obſervation were 88 you muſt make a mark upon your paper againſt 88 degrees, which mark let be B.

3 The degrees cut at your third obſervation were 130, and 45 minutes, therefore againſt 130 degrees 45 min. make a mark upon your paper, which mark let be C.

4 The degrees cut by the Index at your 4th. obſervation being 200 & 30 min (*becauſe it is above 180 degrees, you muſt therefore turn the Semicircle of your Protractor downwards, the line N S lying upon the line M N as before:*) you muſt againſt 120 degrees 30 minutes of your Protractor make a mark upon your paper, which mark is ſignified by D.

5 Seeing the degrees cut at your fifth obſervation were 250, therefore make a mark againſt 250 degrees, which mark is E.

Laſtly, the degrees cut at your laſt obſervation were 310, therefore againſt 310 make a mark, which will be F.

Ha-

Having thus protracted all the degrees of your ſeverall obſervations, you muſt take away your Protractor, and laying a ruler to the center O, draw lines by thoſe points, which lines will be O A, OB, OC, OD, OE, and OF.

This done, you muſt obſerve by your Field-book the length of every line.

As the line O A your firſt obſervation was 40 perches, therefore 40 being taken from your Scale, and ſet upon your paper from O to A, ſhall give you the point A upon your paper.

2 The length of your ſecond line being 45 perches, you muſt take 45 from your Scale, and place it on your paper from O to B.

3 The line O C being 42 perches, you muſt take 42 from your Scale, and ſet it upon your paper from O to C.

And in this manner muſt you proceede with all the reſt of the lines, as O D, O E, and O F.

Laſtly, draw the lines A B, B C, C D, D E, E F, and F A, ſo ſhall you have the exact figure of your Field upon your paper.

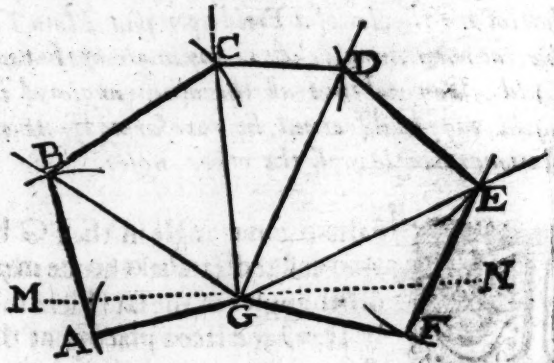
Chap.

Chap. XXXI.

How to take the plot of a Field upon your Plain Table, at one ſtation, taken in any angle of the ſame Field, from whence all the other angles of the Field may be diſcerned, by meaſuring from the ſtationary angle to all the other angles.

REpair to ſome angle in the Field to be meaſured (from whence all the other angles of the ſaid Field may be ſeen) and there place your Inſtrument horizontall, the Needle directly over the Meridian line, and a ſheet of paper ſtretched on your *Table*: then make choiſe of a point on your paper, which ſhall repreſent your ſtation or place of ſtanding, which let be G: then direct your ſights to A, and draw a line upon your paper as G A, and meaſure the diſtance G A as was directed before in *Chap.* 19: then direct your ſights to B, your ſecond mark, and there likewiſe draw a line G B, meaſuring the diſtance G B, as was taught in the forementioned Chapter: In like manner direct your ſights to C, D, E, and F, drawing lines by the ſide of your Index at every obſervation, and mea-

measuring (with your Chain) the distance from G (the place of your standing) to the severall angles of the field A, B, C, D, E, and F, which distances



being taken in your Compasses, from your Scale, and set upon your paper from G, upon the lines GA, GB, GC, GD, GE, and GF, so shall you have upon your paper the marks A, B, C, D, E, and F, by which marks draw lines, as GA, AB, BC, CD, DE, EF, & FG, so shall you have described upon your paper the true figure of your Field.

Chap.

CHAP. XXXII.

How to draw the plot of a Field at one ſtation taken in any angle of the ſame Field, and by meaſuring round about the ſaid Field without croſſing the ſame.

LEt the Figure A B C D E F G be the Figure of a Field to be meaſured.

Having placed marks at the ſeverall angles thereof, and made choiſe of an angle in the ſame to place your Inſtrument, which ſuppoſe at G.

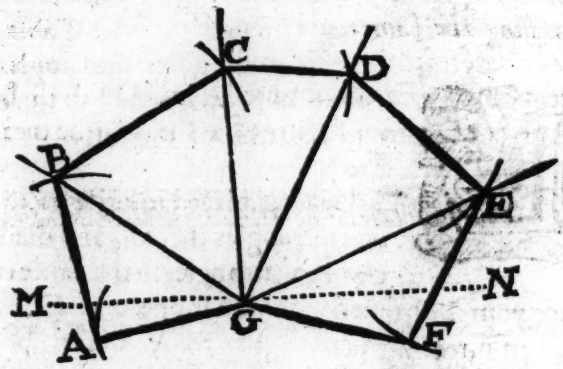
Then directing your ſights to A, draw upon your Table the line G A, then direct your ſights to B, and draw the line G B, then directing your ſights to C, draw the line G C, and conſequently, the lines G D, G E, and G F.

Having thus done, meaſure with your Chain the diſtance from G to A, which let be 40 perches; theſe 40 perches muſt be taken from your Scale, and one foot of the Compaſſes placed in G, with the other draw the arch A, and draw the line G A.

2 Meaſure with your Chain the ſide A B, which ſup-

ſuppoſe 53 perches, this being taken in your compaſſes from your Scale. place one foot in A, and with the other foot draw the arch B.

3 Meaſure the ſide B C 59 perches, and that being taken in your compaſſes from your Scale, place one foot in B. and with the other draw the arch C.



4 Meaſure the ſide C *D* 28 perches, and take that diſtance in the Compaſſes, placing one foot in C, and with the other drawing the arch *D*.

5 Meaſure the ſide *D E* 54 perches, and take that diſtance from your Scale. placing one foot of the compaſſes in *D*, and with the other deſcribe the arch *E*.

6 Meaſure the ſide *E F*, 49 perches, and taking

king that diſtance from your Scale, place one foot of your Compaſſes in E, and with the other draw the arch *F*.

So ſhall theſe ſeverall Arches cut the ſeverall lines *GA*:*GB*,*GC*,*GD*,*GE*, and *GF*, in the points *A*,*B*.*C*,*D*,*E*, and *F*.

Laſtly, by theſe points draw lines from one to another, as, *AB*,*BC*,*CD*,*DE*,*EF*,*FG*, and *GA*, ſo ſhall you have upon your paper on your Table, the exact figure of the field, the ſides and angles thereof being in all reſpects proportionall to thoſe taken according to the doctrine of the laſt.

CHAP. *XXXIII.*

How to take the plat of a Field at one ſtation, taken in any angle thereof, from whence all the other angles may be ſeen, by help of the degrees deſcribed on the frame of the Plain-Table, and by meaſuring from your ſtation to every of the other angles.

PLanting your Inſtrument at G as before, direct your ſights to B, as your firſt mark [*For the line GA, lying under the Meridian line MN muſt be meaſured in the laſt place*] noting the

the degrees cut by the Index on the frame of the Table, which suppose 47 degrees, these degrees must be noted in the first column of your Field-book (as hath beene before sufficiently taught) then with your chain measure the distance from your station at G, to the angle B, which let be 50 perches. which 50 perches place in the third columne of your Field-book, according to former direction.

2 Direct your sights to C, noting the degrees there cut, which suppose 88 degrees 15 minutes, these degrees and minutes place in the first and second columns of your Field-book, then measure the distance GC, 60 perches, and note them in the third columne of your Field-book.

3 Direct your sights to D, the degrees cut being 120, and the distance G D 65 perches, note these in your Field-book as before.

And in this manner must you deale with the other marks E, F, and A, and then having noted them all, your collected notes in your Field-book will be as followeth.

de-

	degr.	min.	perch.	primes.
B	47	00	50	0
C	88	15	60	0
D	120	00	65	0
E	165	30	56	7
F	193	00	40	2
A	348	45	34	0

CHAP. XXXIV.

How to protract or lay down any observations taken according to the Doctrine of the last Chapter.

HAving collected into your Field-book, the quantity of the severall angles, and the length of lines, you may proceede to protraction in this manner.

1 Draw the *Meridian* line *M N*, then make choise of a point therein, representing your stationary angle, as at G. to which point apply the center of your protractor, the Semicircle upwards: Then laying your Field-booke before you, you may perceive that at your first observation (which was at B) your Index cut

cut 47 degrees, therefore make a mark againſt 47 degrees, and draw the line GB.

2 The degrees cut at your ſecond obſervation at C, being 88 deg. 15 min. make a mark likewiſe againſt 88 deg. 15 min. of your protractor, and draw the line G C.

3 The degrees cut at your third obſervation being 120 degrees, make likewiſe a mark againſt 120 degrees of your protractor, and draw the line *G D.*

And in this manner muſt you proceed with the reſt of your obſervations, namely, with the lines CE, GF, and GA.

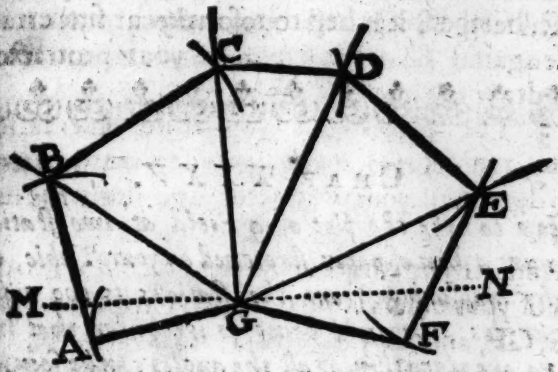
Having thus finiſhed your angular obſervations, proceede now to your lineall, namely to the length of your lines noted in the third and fourth columns of your Field-book.

And ſeeing that the length of your firſt line GB, was 50 perches, you muſt take 50 from your Scale, and apply that diſtance to your paper from G to B.

2 The diſtance of your ſecond line G C being 60 perches, take 60 perches from your Scale, and apply that diſtance to your paper from G unto C.

3 The diſtance of your third mark G *D* being 65 perches, take that diſtance from your Scale, and

and apply it to your paper from the point G unto D.



In all respects as before, you must proceede with the measuring of all the other lines about the field, were there never so many.

Lastly, if you draw the lines A B, B C. C D, D E, E F, F G, and G A, you shall have upon your paper the exact figure of your field.

And herein you may receive abundant satisfaction to see your severall Instrumentall operations, and your Geometricall protraction so exactly to agree: and if at any time you make severall observations of any one piece of ground, according to the directions of the three last Chapters, or

other wise, if you finde them not exactly to agree, you may be sure you have failed in one or other of your observations, and therefore, before you proceed farther, it is best to reform your first errour.

Chap. XXXV.

How to take the plot of a Field at two stations, upon a sheet of paper stretched on your Table, and by measuring from the stations to the visible angles, the field being so irregular that from no one place thereof all the angles can be seen.

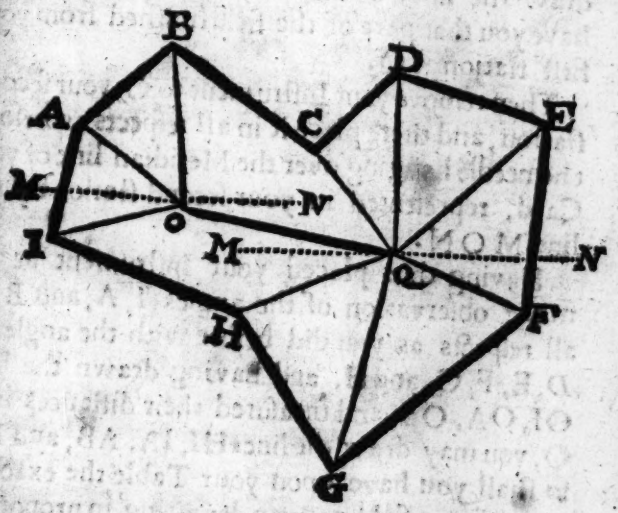
YOu may suppose *A B C D E F G H I* to be the figure of a field to be drawn upon your Plain Table: Now because you cannot from any one place thereof behold all the angles at once, you must therefore make choise of two severall stations, which two stations let be O and Q.

Then upon the paper on your Table, make a mark as Q representing your first station.

This done, place your Instrument at Q, the Needle hanging directly over the Meridian line of your card, as is represented by the line M Q N.

The

The Instrument being there fastned, direct your sights to C, and draw upon your Table the line Q C, measuring the distance from Q to C, and setting that distance on the Table from Q to C. (2) direct your sights to D, and draw the line Q D, measuring the distance Q D as before. (3) direct your sights to E, and draw the line Q E. (4) direct your sights to F, and draw the line Q F,



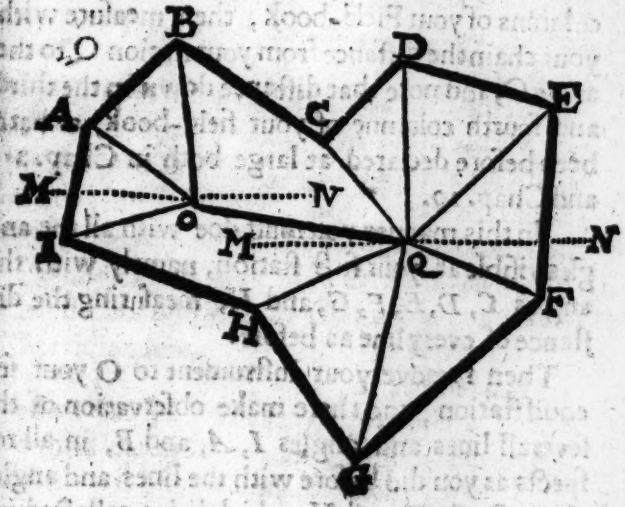
(5) direct your sights to G, and draw the line Q G (6) direct your sights to H, and draw the line Q H (7) direct your sights to O, your second station, and draw the line Q O, measuring the distance from

Q to O, and by your Scale and Compasses, set off your stationary distance upon your Table from Q to O.

Having thus made observation of all the angles visible from the station Q, and drawn lines from Q upon your Table, and likewise measured the distance from Q to every of them, you may then (according to the directions of Chapter 28) draw the lines *CD*, *DE*, *EF*, *FG*, and *GH*, so have you that part of the field finished from your first station at Q.

Then remove your Instrument to O, your second station, and there place it in all respects as before, the needle hanging over the Meridian line of your Card, represented in your second station by the line M O N.

Having thus placed your Instrument at O, make observation of the angles I, A, and B, in all respects as you did before with the angles C, *D*, E, F, G, and H, and having drawn the lines OI, OA, OB, and measured their distances from O, you may draw the lines HI, IA, AB, and BC, so shall you have upon your Table the exact figure of your field no way deviating in proportion from the field it selfe.



CHAP. XXXVI.

How to perform the work of the last Chapter, by the Degrees on the frame of the Table.

THis differeth nothing from the work of the 29 Chapter. Having therefore placed your Instrument at Q, according to the directions of the last Chapter, direct your sights to C, noting the degrees and minutes cut by the Index on the frame of your Table, which degrees

and minutes must be placed in the first & second columns of your Field-book, then measure with your chain the distance from your station Q to the angle C, and note that distance down in the third and fourth columne of your field-book, as hath been before declared at large both in Chap. 21, and Chap. 29.

In this manner you must doe with all the angles visible at your first station, namely with the angles *C*, *D*, *E*, *F*, *G*, and *H*, measuring the distance of every line as before.

Then remove your instrument to O your second station, and there make observation of the severall lines and angles *I*, *A*, and *B*, in all respects as you did before with the lines and angles *C*, *D*, *E*, *F*, *G*, and *H*, which being collected into your Field-book according to the directions of the forecited Chapter 29, they will stand as followeth.

		deg.	m.	perches	prime.
	C	47	15	25	2
	D	88	00	37	0
1 Station Q.	*E*	135	30	35	1
	F	200	00	28	0
	G	270	15	48	4
	H	341	00	33	0

The ſtationary diſtance O Q 50 perches, and the angle O Q M or N O Q 10 degrees, being the declination of your ſtationary line from the Meridian line.

	I	341	30	23	0
2 Station O.	*A*	30	00	21	1
	C	84	45	35	4

CHAP. XXXVII.

How to protract or lay down any obſervations taken according to the directions of the laſt Chapter.

AS the operation of the laſt Chapter differed nothing from that of the 29, ſo the protraction thereof differeth nothing from that of the 30 Chap.

Therefore upon paper or otherwiſe draw the line *M Q N*, and placing the center

ter of your protractor upon Q your first ſtation and make marks againſt every of the degrees of the Angles, as they are noted to you in your Field-book, as namely,

for the firſt angle at C 47 degrees 15 min.
for the ſecond at D 88 degrees.
for the third at E 135 degrees 30 minutes.
And ſo for the reſt.

Then becauſe the ſtationary line O Q declineth 10 degrees from the Meridian line M Q N, therefore, before you move your Protractor from Q, make a mark againſt 10 degrees thereof, and draw the line O Q, which is your ſtationary line, and likewiſe upon that line from Q to O, ſet off 50 perches for your ſtationary diſtance.

Then draw the line M O N parallel to the line M Q N, and upon the point O, place the center of your protractor, making marks at the angles A and B: then turning the Semicircle of the protractor downwards, make a mark at the angle I.

Laſtly, if you draw lines from one angle to another, as the lines A B, B C, C D, D E, E F, F G, G H, H I, and I A, you ſhall have upon your paper the exact proportion of the field, anſwerable to thoſe drawn by the directions of the two precedent Chapters.

According to the directions of the 31, 32, 33, and 34 Chapters, together with the aſſiſtance of this

this Chapter, you may take the plot of any plain field whatsoever by several stations taken in several angles of the same field, if that from one angle you cannot perceive all the other, so that now I think my Surveyor being well exercised in the performance of these 12 last Chapters, he may attempt the drawing of the plot of any plain field whatsoever, and herein practise is better then many words.

Yet notwithstanding, suppose a field were unpassable in respect of waters or the like; I will adde the next Chapter, shewing how to take the plot of any field at two stations taken within the same field, so that all the angles thereof may be seen from both the stations, and by measuring only the stationary distance.

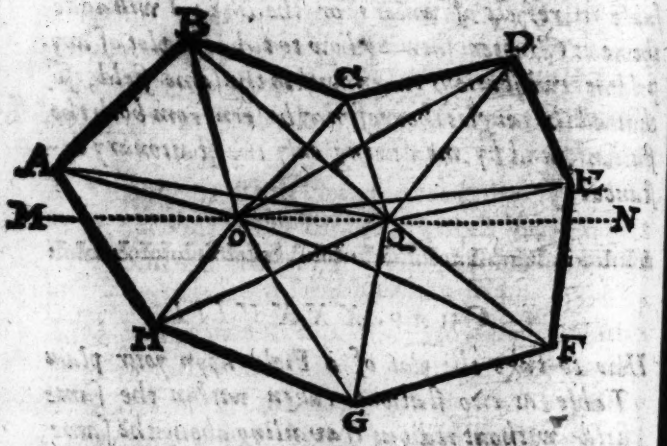
CHAP. XXXVIII.

How to take the plot of a Field upon your plain Table, at two stations taken within the same field, without tedious travailing about the same, by measuring only the stationary distance.

NEcessity may sometimes require the plotting of a field according to the directions which I shall deliver in this Chapter, yet I would advise my Surveyor

veyer to make as little use thereof as he can, in regard of the acuteneſſe of the angles, which is more lyable to errour then any of the former wayes (though grounded upon a firm Geometricall principle.)

Let A, B, C, D, E, F, and G be the figure of a field, and let the two ſtations within the ſame be O and Q.



Having placed your Inſtrument at O, for your firſt ſtation, the needle hanging directly over the Meridian line of the Card, you muſt,

1 Direct your ſights to your firſt angle at A, and draw the line O A.

2 di-

1 direct your sights to B, and draw the line O B.
2 direct your sights to C, and draw the line O C,
3 direct your sights to D, and draw the line O D,
4 direct your sights to E, and draw the line O E,
5 direct your sights to F, and draw the line O F,
6 direct your sights to G, and draw the line O G,
7 direct your sights to H, and draw the line O A.
8

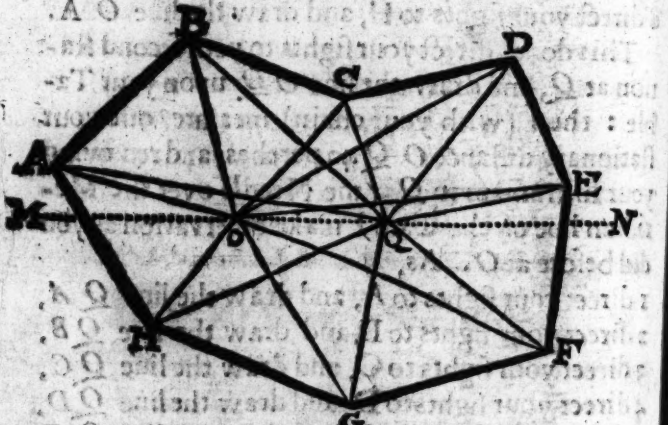
This done, direct your sights to your second station at Q, and draw the line O Q upon your Table: then (with your chain) measure out your stationary distance O Q 40 perches, and removing your Instrument to Q, (the Needle over the Meridian line of the Card) make observation as you did before at O. As,

1 direct your sights to A, and draw the line Q A,
2 direct your sights to B, and draw the line Q B,
3 direct your sights to C, and draw the line Q C,
4 direct your sights to D, and draw the line Q D,
5 direct your sights to E, and draw the line Q E,
6 direct your sights to F, and draw the line Q F,
7 direct your sights to G, and draw the line Q G,
8 direct your sights to H, and draw the line Q H.

Now you may plainly perceive by the figure, where the correspondent lines at each station intersect; as, 1 the lines O A and Q A, intersect or crosse each other at A
2 the lines O B, and Q B intersect each other at B,
3 the lines O C and Q C, intersect each other at C,

4 the

4 the lines *OD* and *QD*, interſect each other at D
5 the lines *OE* and *QE*, interſect each other at E
6 the lines *OF* and *QF*, interſect each other at F
7 the lines *OG* and *QG*, interſect each other at G
8 the lines *OH* and *QH*, interſect each other at H



Therefore if from theſe points of interſection you ſhall draw lines from one to another, you ſhal have upon your paper the exact ſymmetry or proportion of your field, as namely, the lines *AB*, *BC*, *CD*, &c.

And in this kinde of plotting, you cannot but perceive a wonderfull quick diſpatch, you being neither to obſerve Degrees cut, nor to meaſure any di-

distances, save only between your stations, but by reason of the acuteness of the angles (without exact and curious drawing of your lines and observing the precise points of intersection) you may run into grosse absurdities and mistakes.

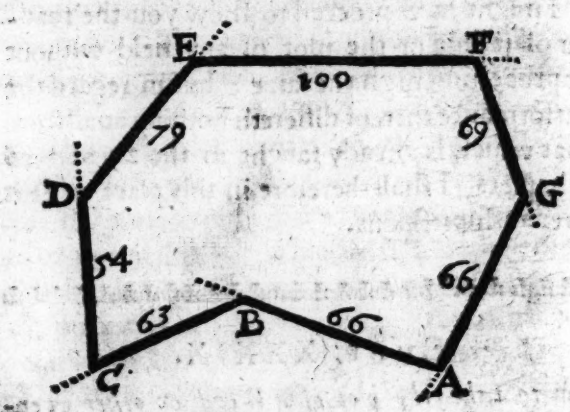
I might now proceed to shew you the manner of taking of the plot of any field without approaching nigh the same; but in regard the performance thereof differeth nothing at all from that which is already taught in the 25 and 26 Chapters, I shall therefore in this place passe it over as superfluous.

Chap. XXXIX.

How to take the plot of a Wood, or other overgrown ground upon your Plain Table, by going round about the same, and making observation at every angle, when by reason of the thicknesse of the wood, or otherwise, you can neither see the angles from any station taken in the midst thereof, nor from any one angle to all the rest.

WE have hitherto treated of plain and open grounds, let us now say somthing concerning Wood-land and such like. Suppose therefore A B C D E F and G, were a piece of Woodland ground to be measured,

ſured: By reaſon of the thickneſſe of the Wood or other oppoſition you cannot come to meaſure the inſide thereof, you muſt therefore work without.



1 Place your Inſtrument at the angle A, and directing your ſights to the next angle at B, and by the ſide thereof draw a line upon your Table, as the line B A: then meaſure by the hedge-ſide, from the angle A to the angle B, which ſuppoſe 66 perches, then from your ſcale take 66 perches, and ſet that diſtance upon your Table from A to B.

2 Remove your Inſtrument from A, and ſet up a mark in the place thereof, and place your Inſtrument at your ſecond angle at B, then lay the Index upon

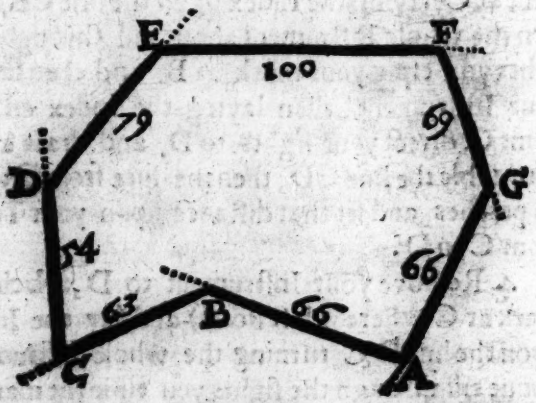
upon the line A B, and turn the whole Instrument about till through the sights you espie the mark which you set up at A, and then with your Screw fasten the Instrument there: then laying the Index upon the point B, direct your sights to the third angle at C, and draw the line B C upon your Table, then measuring the distance B C 63 perches, take that distance from your Scale, and set it on your Table from B to C.

3 Remove your Instrument from B, and set a mark in the room thereof, and place your Instrument at C, laying the Index upon the line C B, and turn the whole Instrument about till through the sights you espie your mark at B, and then fasten your Instrument, then laying the Index on the point C, direct your sights to D, and draw upon your table the line C D, then measure from C to D 54 perches, and set that distance upon your Table from C to D.

4 Remove your Instrument to D, (placing a mark at C where it last stood) and lay the Index upon the line D C, turning the whole Instrument about till through the sights you espie the mark at C, and there fasten the Instrument: then lay the Index on the point D, and direct your sights to E, and draw the line D E, then with your chain measure the distance D E 79 perches, and set that distance

ſtance upon your Table from the point D to E.

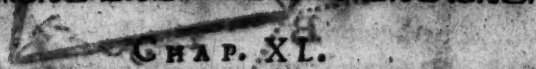
5 Remove your Inſtrument to E (placing a mark at *D* where it laſt ſtood) and lay the Index upon the line *D*E, turning the whole Inſtrument about till through the ſights you eſpie the mark at *D*, and there faſten the Inſtrument: then lay the Index upon the point E, and direct your ſights to F, and draw the line E F, then meaſure the diſtance E F, 100 perches, and ſet that diſtance upon your Table from E to F.



6 Remove your Inſtrument to F (placing a mark at E where it laſt ſtood) and lay the Index upon the line E F, turning the whole Inſtrument about, till through the ſights you ſee your mark at

at E, there fasten the Instrument, and laying the Index on the point F, direct your sights to G, and draw the line F G, then measure the distance F G 60 perches, and set off that distance upon your Table from the point F to G.

7 Lastly, Remove your Instrument to G (setting up a mark at F where it last stood) and lay the Index upon the line F G, turning the whole Instrument about, till through the sights you see the mark at F, and then fasten the Instrument, then laying the Index upon the point G, direct your sights to A (your first mark where you began) and draw the line G A, which shall passe directly through the point A, where you first began, if you have truly wrought.

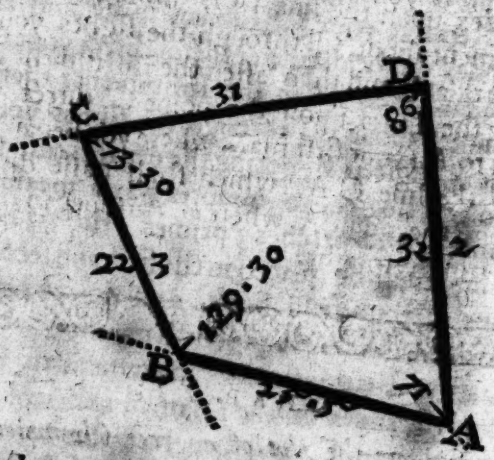


Chap. XL.

How to draw the plot of a great Champian plain by help of the degrees on the frame of the Table.

LEt A B C D be a large Champian plain whose plot is required, first place your Instrument at A, laying the Index on the diameter of the Table, and turning the whole Instrument about, till through the sights you see

the angle at B, then fixe the Instrument there, and turn the Index about till through the sights you espie the angle on the other side of your station at D, noting the degrees cut by the Index, which suppose 71, which is the quantity of the angle B A D: then measure with your chain the distance AD



which is 31 perches 2 primes; the 71 degrees must be noted in the first columne of your field-book, and the 31 perches 2 primes in the third & fourth columnes, as hath been before sufficiently shewn.

3 Remove your Instrument to the next angle at D, and laying the Index on the Diameter thereof, direct your sights to your last station at A, and there

there fixe the Instrument, then turn the Index about till you see the next angle at C, noting the degrees there cut, which suppose 86, which 86 degrees is the quantity of the angle ADC, then measure the distance DC 31 perches, and note the 86 degrees in the first, and the 31 perches in the third columne of your field-book.

3 Remove your Instrument to C and laying the Index on the diameter thereof, direct your sights to *D*, and then fasten the Instrument: then turn the Index about till through the sights you espie the next angle at B, noting the degrees cut, which suppose 73 degrees 30 minutes, and measure the distance CB 22 perches 3 primes, the 73 degrees 30 min. must be placed in the first and second columns of your field-book, and the 22 perches 3 primes, in the third and fourth columns.

Lastly, Remove your Instrument to B, and laying the Index on the Diameter thereof, direct your sights to C, and then fixe the Instrument, then move the Index about till through the sights you see the angle at A where you began, noting the degrees there cut, which are 129 degrees 30 minutes, which is the quantity of the angle CBA, then measure with your chain the distance from B to A 25 perches 5 primes, these 129 degrees 30 minutes, and 25 perches 5 primes must be noted

in your field-book as before, then will they stand thus.

	degr.	min.	perch.	primes
A	71	00	32	2
D	86	00	21	0
	73	30	22	3
B	129	30	25	5

The work of this Chapter may be performed upon your plain Table, the operation differing nothing from what is here delivered, save only that as here you have the angles by the degrees on the frame of your Table, and you must by the other attain them by drawing of lines upon the Table.

CHAP. XLI.

How to protract or lay down any observations taken according to the directions of the last Chapter.

Consider which way your plot will extend, and accordingly draw the line B A, then upon the point A protract an angle equal to the angle BAD 71 degrees, and draw the line A D, then from your Scale take 32 perches

perches 2 primes, and set it upon your paper from *A* to *D*.

Then on the point *D* protract an angle equall to the angle *CDA*, 86 degrees, and draw the line *DC*, then from your Scale take 31 perches, and set it upon your paper from *D* to *C*.

Then on the point C protract an angle of 73 degrees 30 minutes, equall to the angle *DCB*, and draw the line C B, then shall the line C B interset the line B A in B, and so the angle C B A will contain 129 degrees 30 minutes as before, and the lines C B and B A, being measured upon your Scale, will give you the exact lengths as you found them by measuring in the field.

Chap. XLII.

How to know whether you have truly wrought, and whether your plot will close or not, when you make observation at every angle of a field, as you did in Chapter 40.

You must collect the quantity of all the angles found at your severall observations into one sum: then you must multiply 180 degrees by a number lesse by two then the number of angles in the field, and if the product of this multiplication be equall to the totall sum of all your angles, then have you wrought right, otherwise not.

Example.

Let us take the work of the 40 Chapter where the angles found were as followeth,

	deg.	min.
The sum of them being 360 degrees. Now because the field consisted but of four sides, you must multiply 180 degrees by 2 (which is a number lesse by 2 then the number of angles in the field) and the product will	71	00
	86	00
	73	30
	129	30
	360	00

be 360 which exactly agreeth with the ſum of all the angles in the field, as you found them by obſervation.

CHAP. XLIII.

How to finde the Area, or ſuperficiall content of of any plain figure, and to reduce irregular figures into regular forms, and to finde the content thereof.

HAving ſhewne how to draw the plot of any field or other meloſure upon paper, it is now neceſſary to ſhew how the content thereof may be attained, that is to ſay, how many Acres, Roods and Perches, any field ſo plotted doth contain: For the performance whereof, we muſt conſider that the originall of the menſuration of all ſuperficiall figures, ſuch as Land, Board, Glaſſe, or the like, doe depend upon the exact meaſuring of certain regular figures, as the Geometricall Square, the Long Square, the Triangle, the Circle, and the Trapezium: So that any plot of land to be meaſured, if it be not in the form of one of theſe figures it muſt (before it be meaſured) be reduced into

into ſome of theſe forms. I will therefore in the firſt place ſhew you how to meaſure any of the ſaid figures ſeverally by themſelves, and then how you ſhall reduce any other figure (how irregular ſoever it be) into ſome of theſe forms, and then how to meaſure it by the ſame rules: And firſt

Of the Geometricall Square.

A Geometricall Square is a figure conſiſting of foure equall ſides and angles, as is the ſquare PKRV, whoſe ſides PK, KV, VR, and RP, are all equall, namely 6 (either) Inches, Feet, Perches, or any other meaſure whatſoever.

Now

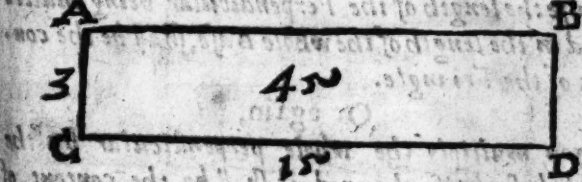
Now to finde the ſuperficiall content thereof, you muſt multiply any of the ſides in it ſelfe, and the product of that multiplication ſhall be the content of the Square.

Examp'e.

Suppoſe the Square PKRV to be a piece of land, and the ſide thereof to contain 6 perches, therefore multiply ſix in it ſelfe (that is 6 by 6) and the product will be 36, and ſo many perches doth the ſquare piece of land PKRV contain, as you may perceive by counting of the little Squares within the great one.

Of the long Square.

A Long Square is a figure conſiſting of 4 ſides, as is the figure *ABCD*, the two oppoſite ſides whereof are equall, as the ſides *AB*, and *CD*, and likewiſe the two other oppoſites *AC* and *BD*, the two ſhorter ſides containing 3 perches, and the longer ſides 15.



To finde the ſuperficiall content of this long Square

Square, you muſt multiply one of the ſhorter ſides by one of the longer, and the product ſhall be the ſuperficiall content thereof.

Exaple.

The longer ſide of the Square contains 15 perches, and the ſhorter 3 perches, now if you multiply 15 by 3 the product will be 45, and that is the content of the ſquare in perches.

Of the Triangle.

THough there be ſeverall kindes of Triangles yet in reſpect they are all meaſured by one and the ſame rule, I will therefore adde but one example for all, which take for a generall rule.

In all right-lined Triangles whatſoever, *Halfe the length of the Baſe being multiplyed by the length of the Perpendicular, ſhall be equall to the Area or content of the Triangle.*

Or,

Halfe the length of the Perpendicular being multiplyed in the length of the whole Baſe, ſhall be the content of the Triangle.

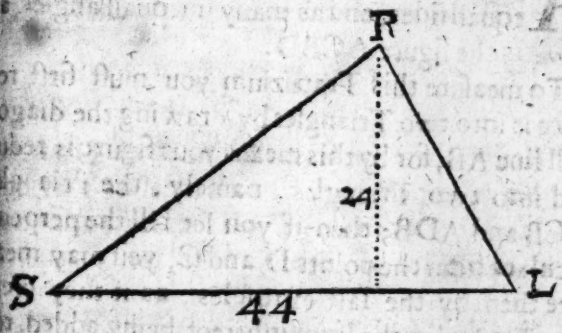
Or again,

If you multiply the whole perpendicular by the whole baſe, halfe the product ſhall be the content of the Triangle.

Ex.

Example.

Suppose you were to finde the Area or content of the Triangle SRQ, first (by the third Proposition of Chapter 9) from the angle R, you must let fall the perpendicular RE, let the length thereof be 24 perches, and the length of the base be 44 perches.



Now if you multiply 12 (which is halfe the length of the perpendicular) by 44 (the length of the whole base) the product will be 528, and that is the area or content of the Triangle.

Or,

If you multiply 24 (the whole length of the perpendicular) by 22 (the length of half the base) the product will be 528 as before.

Or again,

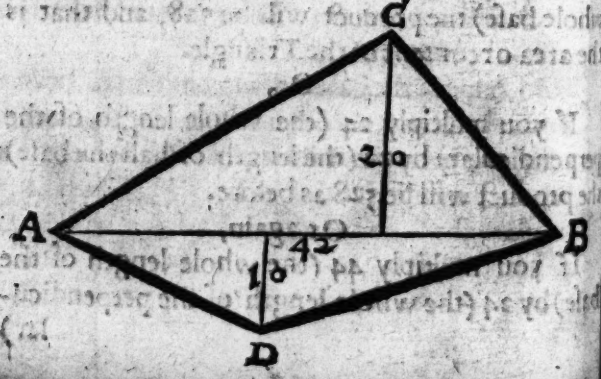
If you multiply 44 (the whole length of the base) by 24 (the whole length of the perpendicular)

lar) the product will be 1056, the halfe whereof is 528, the area or content of the Triangle, as before.

Of the Trapezium.

A Trapezium is a figure consisting of four unequall sides, and as many unequall angles, as is the figure ACBD.

To measure this Trapezium you must first reduce it into two Triangles by drawing the diagonall line AB, for by this means your figure is reduced into two Triangles, namely, the Triangles ACB and ADB; then if you let fall the perpendiculars from the points D and C, you may measure them by the last examples, as if they were two Triangles, the sum whereof being added together will be the area or content of the whole Trapezium.



Example,

Having drawn the line AB, and so reduced the figure into two Triangles, and let fall the perpendiculars from C and D (the base AB being common to both Triangles) Suppose the perpendicular at C were 20 perches, the perpendicular at D 10 perches, and the base AB (serving for both Triangles) 42 perches.

If now according to your former directions, you multiply 42 the base, by 10, halfe the perpendicular, the product will be 420 for the content of the Triangle ACB.

In like manner if you multiply 42 the base, by 5 halfe the other perpendicular, the product will be 210, for the content of the Triangle ADB.

Now if you adde the contents of these two Triangles together, namely 420 and 210, the sum of them is 630, and that is the content of the whole Trapezium ACBD.

But this worke may be performed with more brevity thus.

In respect the base AB is common to both the Triangles, you need therefore do no more but adde the two perpendiculars together, the halfe whereof being multiplyed by the whole base, the product shall be the content of the whole Trapezium.

Example.

The two perpendiculars 20 and 20 being added together, the sum of them is 30, the halfe whereof is 15, this number being multiplyed by 42, the whole length of the common base, giveth 630, the content of the whole Trapezium.

Or,

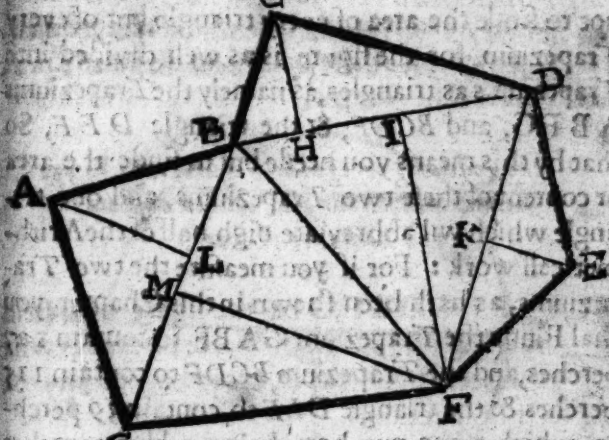
You may multiply the sum of the perpendiculars by the length of the base, and halfe the product shall be the content.

Of the reducing irregular Figures into Trapeziums and Triangles, and to cast up the contents thereof.

LEt ABCDEFG be the figure of a field drawn upon your plain Table, or otherwise protracted upon paper, according to any of the former directions.

In regard that the field is irregular, that is to say, it is neither a Circle, Triangle, Square, or Trapezium, it must therefore (before it be measured) be reduced into some of these forms, which to perform, do thus, draw lines to every other angle, as the lines GB, BD, DF, and FB, then will the whole Figure be reduced into five Triangles, as

1 the triangle GAB,
2 the triangle BCD,
3 the triangle DEF,
4 the triangle FBG,
5 the triangle FBD,



These five triangles must be all measured severally, according to the directions before given, where was shewed how to finde the content of a triangle, and then the contents of all the five triangles being added together into one sum, that sum shall be the area or content of the whole field.

As suppose, the triangle G A B should contain 53 perch-

53 perches, the triangle *BCD* 47 perches, the triangle *DEF* 39 perches, the triangle GBF 74 perches, and the triangle *BFD* 68 perches.

These five numbers being added together make 281 perches, and that is the area or content of the whole field in perches.

But for an abreviation of this work you neede not to finde the area of every triangle, but of every *Trapezium*, for the figure is as well divided into *Trapeziums* as triangles, as namely the *Trapeziums* ABFG, and *BCDF*, & the triangle *DEF*, So that by this means you neede but to finde the area or content of these two *Trapeziums*, and one triangle which wil abbreviate nigh half of the Arithmeticall work: For if you measure the two *Trapeziums*, as hath been shewn in this Chapter, you shal Finde the *Trapezium* GABF to contain 127 perches, and the *Trapezium BCDF* to contain 115 perches & the triangle *DEF* to contain 39 perches, which three numbers being added together produce 181, exactly agreeing with the former.

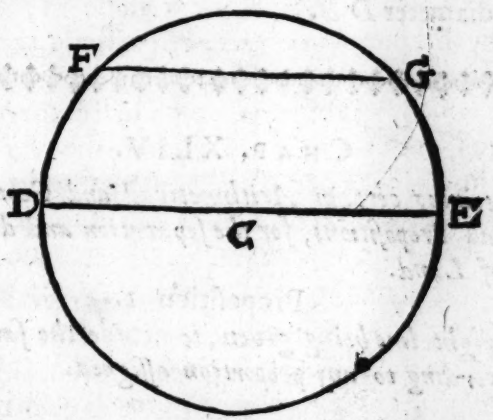
Here note that at any time when you reduce any irreguler plot into triangles, your number of triangles will be lesse by two then the number of the sides of your plot; as in this, the plot consisted of 7 sides, and you see it is reduced into five triangles.

Of

Of the Circle

THe proportion of the circumference of any Circle is to his diameter as 7 to 22.

Now to finde the area or content of any Circle, you muſt multiply the diameter thereof in it ſelfe, and multiply that ſum by 11, which product being divided by 14 ſhall give you the area of the Circle.



Example.

In the Circle *DFGE*, let the diameter thereof *DE* be 28, which multiplyed in it ſelfe giveth 784, this number multiplyed by 11 giveth 8624, which being divided by 14 the quotient will be 616, and that is the area of the Circle.

The circumference of a Circle being given, to finde the Diameter.

MUltiply the circumference by 7, and divide the product by 22, the Quotient shall be the length of the diameter.

Example,

Let the circumference of the Circle *DEFG* be 88, this multiplyed by 7 giveth 616, which being divided by 22 giveth 28, for the length of the diameter *DE*.

CHAP. XLIV.

Conteining certain Arithmeticall and Geometricall Propositions, for the separation and division of Land.

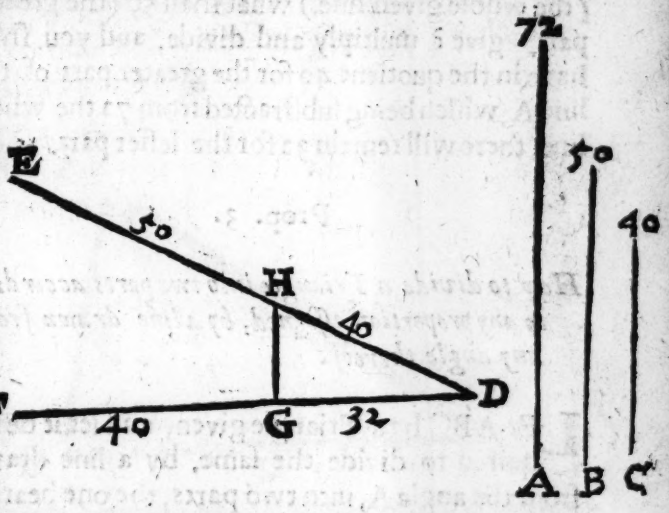
Proposition 1.

A right line being given, to divide the same according to any proportion assigned.

SUppose A be a line given, and let it be required to divide the same into two parts bearing proportion the one to the other, as the line B doth to the line C.

First, draw the line FD, equall

to the given line A, then draw the line ED (to contain any angle at pleaſure, and from D to H place the line C, and from H to E place the line B:



then draw the line EF, and laſtly, draw the line HG parallel to the line EF, which ſhall cut the line F*D* in the point G, ſo is the line F*D*, (which is equall to the given line A) divided in the point G in proportion as the line B is to the line C.

Prop. 2.

To perform the ſame Arithmetically.

LEt the line A be 72, and let the line B be 50, and the line C 40, according to which propor-

tion let it be required to divide the line A.

First say by the rule of proportion, If 90 (which is the sum of the two proportionall terms) give 72 (the whole given line,) what shall 50 (the greater part) give? multiply and divide, and you shall have in the quotient 40 for the greater part of the line A, which being substracted from 72 the whole line, there will remain 32 for the lesser part.

Prop. 3.

How to divide a Triangle into two parts according to any proportion assigned, by a line drawn from any angle thereof.

LEt ABC be a Triangle given, and let it be required to divide the same, by a line drawn from the angle A, into two parts, the one bearing proportion to the other, as the line F doth to the line G.

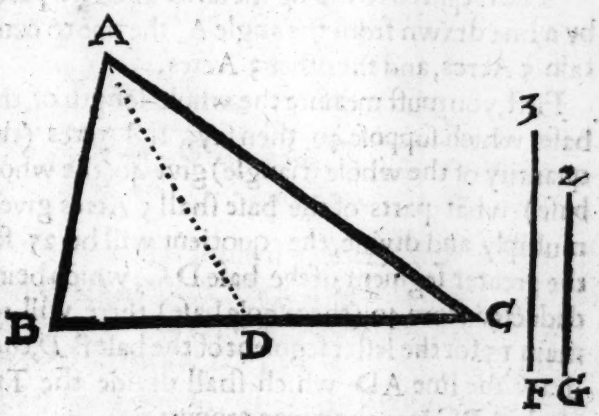
By either of the two last propositions, divide the base of the Triangle B C in the point D, in proportion as the line F is to the line G; then draw the line AD, which shall divide the triangle according to the given proportion.

Prop.

Prop. 4.

The Base of the Triangle being known to perform the former proposition by Arithmetick.

SUppose the Base B C to be 40, and let the proportion into which the Triangle is to be divided be as 2 to 3.



First adde the two proportionall terms together, 2 and 3, which makes 5, then say by the rule of proportion, If 5 (the sum of the proportionall terms) give 40 (the whole base,) what shall 3 (the greater term) give? Multiply and divide, and the quotient will give you 24, for the greater segment of the base *D C*, which being deducted from the whole base 40, there will remain 16 for the lesser segment B*D*

Prop.

Prop. 5.

To divide a Triangle, whose area or content is known, into two parts, by a line drawn from an angle assigned, according to any proportion required.

LEt the Triangle ABC contain 8 Acres, and let it be required to divide the same into two parts by a line drawn from the angle A, the one to contain 5 Acres, and the other 3 Acres.

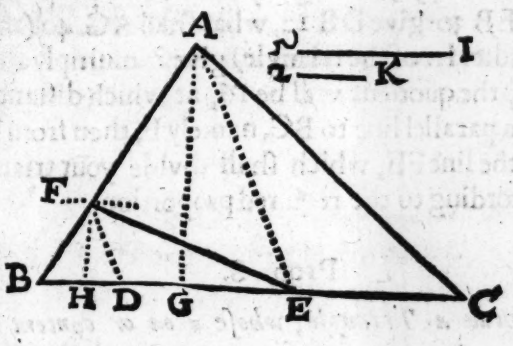
First, you must measure the whole length of the base, which suppose 40, then say, If 8 Acres (the quantity of the whole triangle) give 40 (the whole base) what parts of the base shall 5 Acres give? multiply and divide, the quotient will be 25 for the greater segment of the base D C, which being deducted from 40 (the whole base) there will remain 15 for the lesser segment of the base B *D*, then draw the line AD, which shall divide the Triangle ABG into the given proportion.

Prop. 6.

To divide a Triangle given into two parts, according to any proportion assigned by a line drawn from a point limited in any of the sides thereof.

LEt the Triangle given be ABC, and let it be required from the point E, to draw a line that shall

divide the Triangle into two parts, bearing proportion the one to the other, as the line I doth to the line K.



First, from the limited point E draw a line to the opposite angle A, then divide the base B C in proportion as I to C, which point of division will be at D, then draw *DF* parallel to AE, lastly, from F draw the line F E, which wil divide the triangle as I to K,

Prop. 7.

To perform the same Arithmetically.

LEt it be required to divide the Triangle A B C from the point E, into two parts in proportion as 5 to 2.

First,

First, divide the base BC according to the given proportion, then (because the lesser part is to be laid towards B) measure the distance from E to B, which admit 30, then say by the rule of proportion, If EB 30 give DB 12, what shall AG 40 (the perpendicular of the triangle) give? multiply and divide, the quotient will be 16, at which distance draw a parallel line to BC, namely F, then from F draw the line FE, which shall divide your triangle according to the required proportion.

Prop. 8.

To divide a Triangle, whose area or content is known, into two parts, from a point limited in any side thereof, according to any number of Acres, Roods or perches.

LEt the triangle be ABC, whose quantity is 5 Acres, 1 Rood, let the limited point be E in the base, and let it be required from E, to divide the triangle into two parts between M and N, namely, to M 3 Acres 3 Roods thereof, and to N 1 Acre 2 Roods.

First, reduce the quantity of N (being the lesser) into perches, which makes 240, then (considering on which side of the limited point this part is to be laid, as towards B) measure that part of the base from E to B 30 perches, whereof take halfe, which

which is 15, and thereby divide 240, the part of N, the quotient will be 16, the length of the perpendicular FH, at which parallel distance from the base BC, cut the side AB in F, from whence draw the line FE, which shall include the Triangle FBE, containing 1 Acre 2 Roods, and the Trapezium AFEC contains the residue, 3 Acres 3 Roods.

Prop. 9.

How to divide a given Triangle by a parallel line to one of the sides, according to any proportion given.

LEt the following triangle ABC be given, and let it be required to divide the same into two parts by a line drawn parallel to the line AC, and in proportion as the line I to the line K.

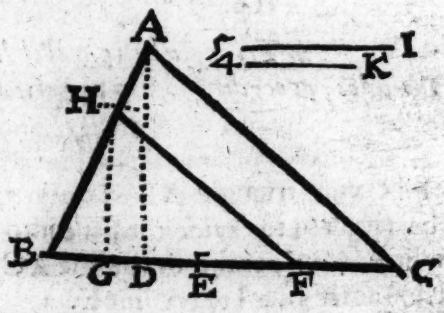
By the first proposition of this Chapter, divide the line BC in E, as I to K, then finde the mean proportion between BE and BC, which let be BF, from which point draw the line FH parallel to AC, which line shall divide the triangle into two parts, the Trapezium AHFC having such proportion to the triangle HBF as I to K.

Prop.

Prop. 10.

To perform the ſame Arithmetically.

LEt the triangle be ABC, and let it be required to divide the ſame by a parallel line to one of the ſides, into two parts, to be in proportion the one to the other, as 4 to 5.



Firſt, let the baſe BC 54 be divided according to the proportion given, ſo ſhal the leſſer ſegment be BE 24, and the greater EC 30; then finde out a mean proportionall between BE 24, & the whole baſe BC 54 by multiplying 54 by 24, whoſe product will be 1296, the Square root whereof is 36, the mean proportionall ſought, which is BF, then by the rule of proportion ſay: If BF 36, give *BE* 24, what *AD* 48? the anſwer is, HG 32, at which diſtance draw a parallel line to the baſe, to cut the ſide

side A B in H, from whence draw the line H F parallel to A C which shall divide the triangle as was required.

Prop. 11.

To divide a Triangle of any known quantity, into two parts, by a parallel line to one of the sides, according to any number of Acres, Roods, and Perches.

LEt the triangle given be A B C, whose quantity is 8 Acres, 0 Roods, 16 Perches, and let it be required to divide the same (by a line parallel to the side A C) into two parts, as 4 Acr. 2 Roo. 0 Perches, and 3 Acres 2 Roods, 16 Perches.

First, Reduce both quantities into perches, (as is hereafter taught) and they will be 720 and 576; then reduce both those numbers by abbreviation into the least proportionall term, which is $\frac{5}{4}$ and according to that proportion divide the base B C 54 of the given Triangle, as is before taught in the two last Propositions, which will be in E, then seek the mean proportionall between B E, and B C which proportionall is B F 36, of which 36 take the half and thereby divide 576 the lesser quantity of Perches the Quotient wil be H G 32 at which parallel distance from the base, cut the line A B in H, from whence draw the line H F ad-

parallel to the ſide AC, which ſhall divide the triangle given into the two parts required.

CHAP. XLV.

How to lay out ſeverall quantities in Common-Fields unto ſeverall Tenants.

YOu muſt (according to the directions before given) plot the whole Field, Common, or other Severall, with its particular bounds as you obſerve them in the ſurvey of the whole Mannor, or if you only ſurvey that particular, you muſt take ſpeciall notice of all the bounds thereof, then provide a particular booke or paper, which muſt be ruled or divided into 10 columns, in the firſt whereof, towards the left hand, is to be written the Tenants name, and the tenour by which he holds the ſame land, the next three columns are to containe the breadth of every mans parcell of land, noted over the head of every Columne with theſe three Characters 0 1 2 anſwering to the ſeverall diviſions of your chain, 0 ſignifying Vnites, 1 ſig-

1 ſignifying Primes, & 2 ſignifying Seconds.

In the next three columnes is expreſſed the length of every tenants parcell, having the like Characters of Unites, Primes, and ſeconds, over the head of each columne, as that of the breadth had.

In the three laſt columns is to be expreſſed the quantity of each tenants parcell.

In the laying out of ſeveral parcels in this kinde, you will have uſe only of your Chain; then when you begin your work you muſt firſt write the name of the field, and in the firſt columne of your booke or paper, you muſt write the Tenants name, and the tenour by which he holds the ſame, from what place you begin to meaſure, and upon what point of the compaſſe you paſſe from thence, and obſerving this direction in all the reſt, you may (if need require) bound every parcell.

This being noted in your book, obſerve the ſpecies or ſhape of the furlong, whether it be all of one length or not, if all of one length, then you need take the length thereof but once for all, but if it be irregular, that is, in ſome places ſhorter and in others longer, then you muſt take the length thereof at every ſecond or third breadth, and expreſſe the ſame in your booke under the title of length. As for the expreſſing of the ſeverall breadths, you need but to croſſe over the whole

Fur-

Furlong, taking every mans breadth by the middle thereof, and entering the ſame as you paſſe along, but in caſe there be a conſiderable difference at either end, then I would adviſe you to take the breadth at either end, & ad them together into one ſum, then take the halfe of that ſum for your mean or true breadth, and enter it in your booke or paper under the title of breadth.

In this manner you may proceed from one Furlong to another till you have gone through the whole field, which when you have done and noted down the ſeverall lengths and breadths in your Booke, you may multiply the length and breadth of every parcell together, as is taught in the next Chapter, and ſo ſhall you have the quantity of every parcell by it ſelfe, which quantity muſt be noted down in the three laſt columns of your Book, as in the following example appears.

Lepham Field.

Tenants names	breadth			length			quantity		
	0	1	2	0	1	2	a	r	p
William Smith, from the back lane Eastward, free	6	8	2	16	2	0	0	2	30
John Esum for two Lives.	1	3	2	16	2	0	0	0	21
James Milson by Copie.	5	6	3	15	4	2	0	2	7
Nicholas Wilde at Wil.	8	4	1	14	2	3	0	3	0

Chap. XLVI.

Shewing how to multiply the ſeverall Fractions of your Chain together, as if they were whole numbers.

Uppoſe you were to multiply 16 Unites 2 Primes (which is the length of your firſt parcell in the foregoing Table) by 1 Unite, 3 Primes, 2 Seconds, (which is the breadth of the ſame parcell) you muſt place your numbers in all reſpects as if they were whole numbers, but over every fraction of your multiplicand you muſt place a prick or point, as in this example, the multiplicand contains only one fraction, which is 2, over which 2 place a prick or point, and at the end of your multiplyer place as many points as there are fractions contained in that number, which in our example are two, *viz.* 3 and 2, behinde which figures I place two pricks, and the numbers will ſtand thus, under which draw a line, and multiply theſe

.	
162	
132..	

these two numbers together in all respects as if they were whole numbers, and then the work will stand thus, the product of your multiplication being 21384. Now because in your two numbers, *viz.* your multiplicand and your multiplyer, there are three fractions, namely, one in your multiplicand, and two in your multiplyer, you must therefore with a dash of your pen cut off the three last figures of your product towards your right hand; and then will your product stand thus. the three last figures whereof are the numerator of a fraction, whose denominator is 1000, and the other two figures towards your left hand are Integers of your multiplication; so that the sum of this multiplication is 21 perches, and $\frac{384}{1000}$ parts of a perch, which is something more then a third part of a perch.

	162
	132
	324
	486
	162
	21384
	21|384

But to expresse the exact quantity of these fractions, in a businesse of this nature, were superfluous, only observe this one rule for all, namely, that if the figures cut off come neere to a unite, that is, when the figures cut off are neere as much as those underneath them, or the first of them cut off are either 7, 8, or 9, you may then increase your whole

number by a unite, and not at all regard the fraction.

But for your better practice take another example, which let be the third in the foregoing Table, where the breadth is 5 unites, 6 primes, 3 seconds, and the length 15 unites, 4 primes, & 2 seconds, which being placed according to the former directions they will stand thus.

	1542
	563..

Now if you multiply these one by another as if they were whole numbers, then they would stand thus, the product being 868146 from whence taking the foure last figures (because there are foure fractions in your two numbers, there remains 86 perches, and $\frac{8146}{10000}$ parts of a perch, now because 8146 is neere to 10000, I adde 1 to 86, making 87 perches, wholly neglecting the smallnesse of the fraction taken in over and above.

	..
	1542
	563..
	4626
	9252
	7710
	86|8146

In like manner, suppose you were to finde the quantity according to the second row in the foregoing Table, the breadth being 1 unite, 3 primes, 2 seconds, and the length, 16 unites, 2 primes, which must be placed thus, and being being multiplyed as whole

	..
	132
	162.

num-

numbers will ſtand thus, and produce this product, 21384 from whence cut off the three laſt figures (becauſe there were three fractions in your numbers multiplyed) and there will remaine 21 perches, and $\frac{384}{1000}$ parts of a perch, which being but of ſmall value you may reject.

	132
	162.
	264
	792
	132
	21384

CHAP. XLVII.

How to reduce Perches into Acres, and the contrary.

ACcording to the Statute of 33 *Edw.* 1. an Acre of ground ought to contain 160 ſquare Perches, and in every Rood of Land 40 ſquare Perches: Therefore if any number of perches be given to be turned into Acres, you muſt divide the number given by 160 (the number of perches contained in an Acre) and the quotient ſhall ſhew you how many Acres are in that number of perches, but if any thing remain (if it be under 40) it

must be perches; but if the remainder exceed 40, then you must divide it by 40 (the number of perches contained in one Rood) and the Quotient shall be Roods, and the remainder Perches.

Example.

Let 5267 perches be given to be reduced into Acres, first divide 5267 by 160, and the quotient will be 32, and 147 remaining, which divide by 40, the quotient will be 3, and 27 remaining, so that the whole amounteth to 32 Acres, 3 Roods, and 27 Perches.

In like manner, let 5496 perches be given to be turned into Acres, first divide 5496 by 160, the quotient will be 34 and 56 remaining, which 56 being divided by 40, the quotient will be 1 and 16 remaining, so that the whole will be 34 Acres, 1 Rood, and 16 perches

How to reduce Acres into Perches.

THis is but the converse of the former, for whereas before, to bring Perches into Acres, you divided by 160, you must now, to turn Acres into Perches multiply by 160. *Example.*

Let 32 Acres, 3 Roods, and 27 Perches, be given to be reduced into Perches: first, multiply the 32 Acres by 160, and the product will be 5120, then multiply the 3 Roods by 40, the

the product is 120, these two products, and the 27 perches being added together, the sum will be 5267, and so many perches are contained in the foresaid number of Acres, Roods, and Perches.

	5120
	120
	27
	5267

Chap. XLVIII.

How to reduce Statute Measure to Customary measure.

According to the forenamed Statute of 33 *Edw.* 1. an Acre of ground was to contain 160 square perches, measured by the Pole or Perch of 16 foot and a halfe, but in many places of this Nation, through long custome, there have been received other quantities, called Customary, as namely 18, 20, 24, and 28, foot to the Pole or Perch.

It is therefore of extraordinary use for a Surveyor to know how readily to reduce Customary measure to Statute measure, and the contrary.

Let it therefore be required to reduce 5 Acres, 2 Roods, 20 Perches, measured by the 18 foot Pole

into Statute measure, you must seeke out the least proportionall terms between 18 foot and 16 and a halfe, which to perform do thus. Because 16 and a halfe beareth a fraction, reduce the 16 and a halfe into halves, and because they may be both of one denomination, you must reduce 18 (the customary pole) into halves also, then will they stand thus: $\frac{33}{36}$ which abreviated by 3, by saying how many times three in 33? the answer will be 11, and again, how many times three in 36? the answer will be 12; so will the two proportionall terms between 16 and a halfe. and 18, be 11 & 12.

This done, reduce your given quantity (5 Acres, 2 Roods, and 20 perches) into perches, which makes 900 perches: Now considering that what proportion the square of 11 which is 121, bears to the square of 12, which is 144, the same proportion doth the Acre of 16 foot and a halfe pole beare to the Acre of 18 foot.

Now because the greater measure is to be reduced into the lesser, multiply the given quantity 900 perches by 144 the greater square, and the product will be 129600 which divided by 121 the quotient will be $1071\frac{9}{121}$ perches, which being reduced into Acres giveth 6 Acres, 2 Roods 31 perches, and $\frac{9}{121}$ parts of a perch for the quantity of Acres according to Statute measure.

But

But on the contrary, ſuppoſe it had beene required to reduce Statute meaſure into cuſtomary meaſure, then you muſt have multiplyed 900 perches (your given quantity) by 121 the leſſer Square, (becauſe the leſſer meaſure is to be reduced into the greater) the product will be 108900, which divided by the greater Square 144, the quotient will be 756¼, which reduced into Acres is, 4 Acres, 2 Roods, 36 perches and a quarter.

The like courſe is to be obſerved with any other cuſtomary quantity, as when you meaſure with the pole or perch of 20, 24, or 28 foot.

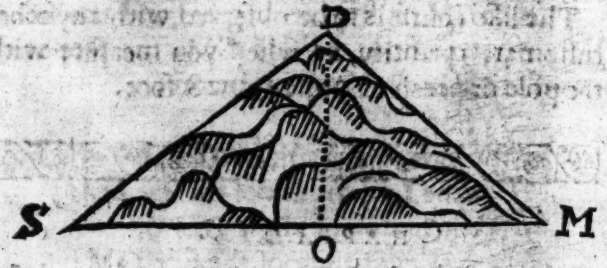
CHAP. XLIX.

How to finde the horizontall line of any hill or Mountain.

THis propoſition differeth nothing from thoſe before ſhewn in the taking of altitudes.

Wherefore ſuppoſe you ſhould meet with the hill or mountain SDM, the thing required is to finde the length of the line SM on which the mountain ſtandeth: Firſt place your Inſtrument at S exactly levell, then let

let one goe to the top of the hill at D, and there place a mark which must be so much above the top of the hill as the top of the Instrument is from the ground on which it standeth, then the Quadrant being placed upon the index of the Table, move it up and down till through the sights thereof you see the top of the mark at D, then note the degrees cut by the Index of the Quadrant, and



that is the quantity of the angle DSO, which suppose 42 degrees, then by consequence the angle SDO must be 48 degrees, the complement of the former to 90 degrees, then measure the side of the hill SD, which suppose 50 foot; then in the triangle DSO you have given, first, the side D S 50 foot, secondly, the angle DSO 42 degrees, thirdly, the angle SDO 48 degrees, together with the right angle DOS 90 degrees, and you are to finde the side SO, which to perform say,

As

As the Sine of the angle DOS, or the sine of 90 de.
is to the Logarithme of the side S D,
So is the Sine of the angle S D O.
to the Logarithme of the side S O
Which will be found to be about 37 foot.

Then because the hill descends on the other side, you must place your Instrument at M, and make like observation as before, observing the angle DMO to be 30 degrees, and then by consequence the angle ODM must be 60 degrees, and the side DM 70 foot, to finde the side GM, the proportion will hold in all respects as before.

For,

As the Sine of the angle *DOM*,
Is to the Logarithme of the side *DM*,
So is the sine of the angle *ODM*,
to the Logarithme of the side OM:

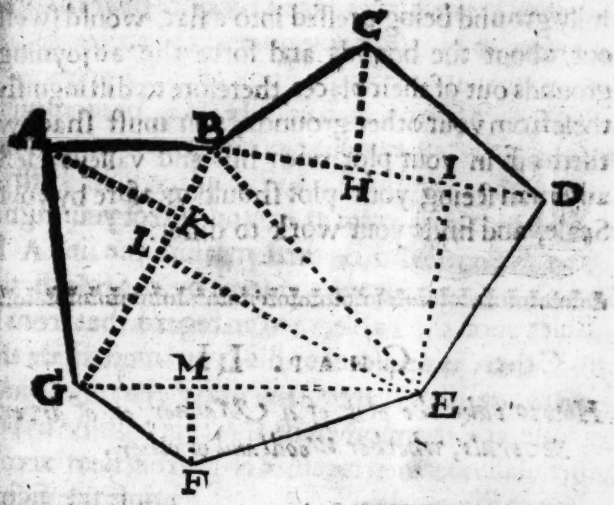
Which will be found to be about 60 foot and a halfe, which added to the line SO 37 foot, the sum is 97 foot and a halfe, and that is the length of the line SM, which line is to be protracted instead of the hypothenusall lines *SD* and *DM*.

Chap. L.

How to protract or lay down mountainous and uneven grounds, with the beſt way to finde the area or content of ſuch irregulars.

LEt ABCDEFG be a mountainous piece of ground to be meaſured: Firſt, place your Inſtrument at A, and direct your ſights to B, then meaſure the line A B, draw the ſame by the ſide of the Ruler upon the Table, then in regard that from B to C there is an aſcent or hill, you muſt finde the horizontall line thereof, and draw that upon your Table, accounting thereon the length of the hypothenuſall line, then meaſure round the field according to former directions, and having the figure thereof upon your Table, reduce it into Trapeziums, as ABEG, and BCDE, and the Triangle GEF, then from the angles ACE and F let fall the perpendiculars. Now in reſpect there are many hils and valleys all over the field, you muſt meaſure with your chain in the field over hill and dale, from B to D, and to the line B*D* ſet the number of perches as you finde them by meaſuring, which will

wil be much longer then the ſtreight line *BD* meaſured on your Scale; then by help of your Inſtrument finde the point H in the line *BD*, and meaſure with your chain from C to H over hill and dale as before, and to the perpendicular CH, ſet



the number as you finde it by the Chain; then likewiſe finde the perpendicular I E, and meaſure that with your chain likewiſe, all which lines (in reſpect of the hils and valleys) will be found much longer then if they were meaſured by your Scale: then by the meaſured lines *BD*, *CH*, and *IE*, caſt up the content of the Trapezium *BCDE*, and in

this

this manner you must cast up the content of the Trapezium ABEG, and the Triangle GEF, and this is the exactest way I can prescribe for the mensuration of uneven grounds, which being well and carefully performed, will not vary much of the true content For you must needs think that any hilly ground being pressed into a flat would swell out about the bounds and force the adjoyning grounds out of their places, therefore to distinguish these from your other grounds, you must shadow them off in your plot with hils and valleys, lest any man seeing your plot should measure by your Scale, and finde your work to differ.

Chap. LI.

How to take the plot of a Manner, or of divers Severals, whether Woodland or other.

Although practise in the performance hereof be better then many words, and that the rules already delivered are of sufficient extent to perform the work of this Chapter, yet I will herein deliver the most sure and compendious way I can imagine.

imagine. Suppoſe therefore that the following figure were part of a Mannor, as the Mannor of *Goſſe*, you muſt firſt write the title thereof in your field-book, thus,

Maner de Goſſe in Com: Eſſ: pro Reg. incip. 2 Mar. 1631.

Then having your field-book in a readineſſe, ruled and fitted as is taught in Chapter 8. write over every Cloſe as you Survey, the tenants name, the name of the Cloſe, and the tenour by which he holds the ſame: As in the following example, for the firſt Cloſe, *John Jones Boes Cloſe paſture, free.* Then beginning to ſurvey this parcell, which is *Boes Cloſe*, Firſt, place your Inſtrument at A, and direct your ſights to B, noting the degrees there cut, which let be 195, which 195 degrees muſt be noted in the firſt columne of your field-book, then meaſure with your Chain the diſtance from A to B, and you ſhall finde it to contain 30 perches 4 primes, which place in the third and fourth columns.

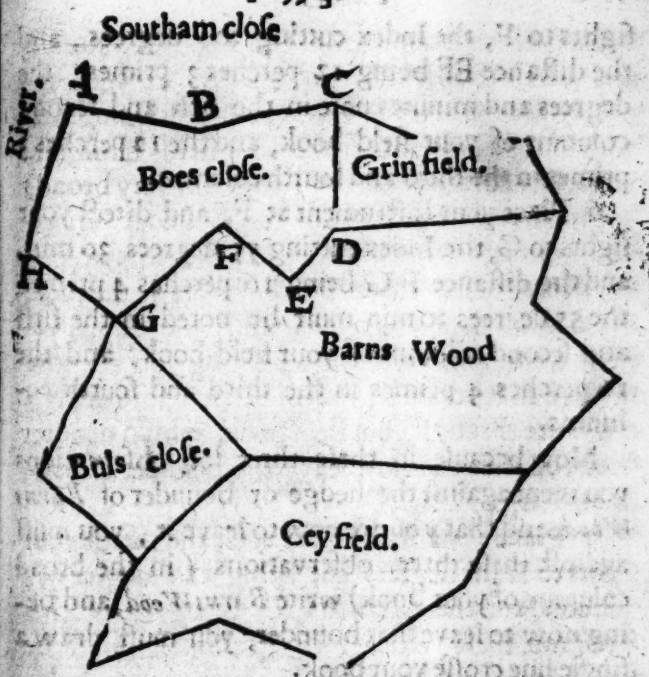
2 Remove your Inſtrument to B, and direct your ſights to C, the Index cutting 205 degrees 30 min. which note in the firſt & ſecond columns of your field book, then meaſure the diſtance B C, 26 perches 7 primes, which note in the third and fourth columns. Then in regard you are to leave the hedge or bounder ABC, adjoyning to *Southam*

Cloſe

Close (which is appertaining to another Mannor, and therefore only the name inserted for your remembrance when you come to protraction) you must draw a line quite crosse your field-book, and in the last columne thereof (which is very broad) you must write the name of the bounder which you went against, as in the example, these two observations being mape by the hedge or bounder of *Southam close*, you must against those observations write *Southam Close*, and being you are now to leave that bounder, you must therefore draw a line quite through your field book, which denotes unto you that you now leave the bounder of *Southam Close*.

3 Place your Instrument at C, and direct your sights to D the degrees cut being 120 degrees 45 minutes, and the distance CD being 27 perches 8 primes, these 120 degrees 45 minutes must be noted in the first and second columns of you field-booke, and the 27 perches 8 primes in the third and fourth. Now because at these three observations you went against the hedge or bounder of *Grin field*, you must against them (in the broad columne of your field booke) write *Grin field*, and because at your next observation you are to leave that bounder, you must therefore draw a line cros your booke, denoting that you have done with that bounder.

4 Place



4 Place your Instrument at *D*, and direct your sights to E, the index cutting 86 degrees 15 min. and the distance *DE* being 10 perches 4 primes, the degrees and minutes must be noted in the first and second columns of your field-book, and the 10 perches 4 primes, in the third and fourth columns.

5 Remove your Instrument to E, and direct your sights

ſights to F, the Index cutting 300 degrees, and the diſtance EF being 12 perches 3 primes, the degrees and minutes note in the firſt and ſecond columns of your field book, and the 12 perches 3 primes in the third and fourth columns.

6 Place your Inſtrument at F, and direct your ſights to G, the Index cutting 55 degrees 30 min. and the diſtance F G being 16 perches 4 primes, the 55 degrees 30 min muſt be noted in the firſt and ſecond columns of your field-book, and the 16 perches 4 primes in the third and fourth columns.

Now becauſe in theſe three laſt obſervations you went againſt the hedge or bounder of *Barns Wood*, and that you are now to leave it, you muſt againſt theſe three obſervations (in the broad columne of your book) write *Barns Wood*, and being now to leave that bounder, you muſt draw a ſingle line croſſe your book.

7 Place your Inſtrument at G, and direct your ſights to H, the Index cutting 324 degrees 15 min. and the diſtance GH being 36 perches 2 primes, the degrees and minutes muſt be noted in the firſt and ſecond columnes of your field-book, and the perches and primes in the third and fourth.

8 Remove your Inſtrument to H, and direct your ſights to A (where you began) the Index cutting 107 degrees 15 min, and the diſtance HA being

ing 34 perches 6 primes, the degrees and minutes must be noted in the first and second, and the perches and primes in the third and fourth columns of your field-book, as before. Now because in these two last observations you went by the Rivers side, you must therefore against them write *The River*, and because you have now finished your first close, you must draw a double line for your remembrance.

Then consider which close is next fitting to be taken in hand, which let be *Grin field*, and withall at what angle thereof it is most meet to begin, which let be at C; and here (for your help when you come to protraction) you must expresse in the Title of this second close at what angle you begin the same, (unlesse you had begun it where you ended the last, and then it is not materiall) wherefore seeing you are best to begin at C, look in your book on the work of your last close, at what place the line B C ended, as at the end of 205 degrees 30 minutes, and 26 perches 7 primes, and therefore against that number, make this ⊙ or any other mark on the right side of your downright lines, and then write your Title for your second close, thus:

William Harding Grin Field free.

begin at ⊙

By this means you shall readily know when

you come to protraction, where to begin with this close, and in the Margine place (2) for the number of your second Close, and then proceed in your work as before is taught for the last Close till you come to K, where noting that you want but one line, as K D to inclose this second Close, and also that this Angle R is the fittest place to begin your third Close at, placing there your Instrument & directing your sights to D, where you are to inclose, and then write in the Margine of your book (against the degree here taken) draw a short line as thus ——21 30 40 2, which serves to put you in minde, when you come to protraction, that you are to begin your third field where now you are at the Angle K, where you took your last Sight: and then having inclosed this second close, proceed to the third from K, in the title whereof you need not make mention at what place you begin for the former reason, but working in that and all the rest as before is taught, and if there were never so many inclosures you may (without confusion) easily distinguish the work of the one from the other, and be able (remembring the premises) to draw a plot thereof at any time, remembring alwayes that these numbers in the Margent of your Booke are to be placed severally in your Plot, in those Closes they represent: And by this means you are ea-

eased of much trouble that you must by the other way be put to in protracting upon the Table it self, for then in every plot you must write the name of the Tenant or the Close or the tenure or quality thereof, which breedeth confusion, and occasioneth much trouble in casting up the contents.

These instructions being sufficient for the application and use of the field book, I shall desire my Surveyor often to make practise thereof, and compare his book with the plot and protracting the same according to the directions hereafter given he shall find it to be most exact and facile.

Here by the way I might give my Surveyor some directions whereby to take in divers severalls at once, when their bounds are regular by onely noting the ends or extremities thereof, which will much ease him both in Surveying and protracting, as by a little practise he will quickly finde.

Here followeth the figure of one leafe of your Field-book as it ought to be ruled, which take for an example, it being the collections of the preceding example.

John Jones, Boes Close, patture, free.					
	de.	ac.	p.	yr.	
(1)	195	00	30	4	Southam Close.
	205	30	26	7	⊙
	120	45	27	8	Gon Field
	86	15	10	4	Barns Wood.
	300	00	12	3	
	55	30	16	4	
	324	15	36	2	The River.
	106	15	34	6	
William Harding, Grin field, free.					
					from ⊙
(2)	160	00	12	3	The Common.
	189	45	16	2	
	95	15	14	7	
	21	30	40	2	—— Barns Wood.
William Haron, Barns Wood for life.					
(3)					

And here I will adde one abbreviation in the precedent work which is this.

Having placed your Instrument at A, direct your Sights to B, and measure the distance A B. then remove your Instrument to C, and by your back sights look towards B, and measure the distance B C, then direct your sights to *D*, and measure the distance C D; then remove your Instrument to E, and by your back sights look towards D, and measure the distance D E, and so proceed round the field, placing your Instrument at every other angle, and here you must note, that in taking your back sights, you must always number your degrees, cut by one, and the same end of the Index.

CHAP LII.

How to protract or lay down any observations taken according to the direction of the last Chapter.

PRovide a skin of Velom, or Parchment, or divers sheets of paper, neatly fastned together with starch or Mouth-glew (according to the magnitude or greatnesse you intend to have your plot: which

paper, or parchment, let be ruled all over with occult parallel lines, representing *Meridians*, the distance of which lines must not exceed the breadth of the Scale of your protractor.

Then suppose you were to protract the observations of the last Chapter, laying your field-book before you, consider which way your plot will extend, and accordingly begin your work, which let be at the point A. upon which point place the center of your protractour, turning it about till the correspondent divisions at each end of the Scale thereof, lie directly upon one and the same parallel meridian; and staying your protractor there, look in your field-book, for the degrees cut by the Index at your first observation, and against that division of your protractour place your protracting pin, holding it there till you bring the Scale of your protractor to lie directly thereupon, the beginning (or first number of your Scale lying upon the point A) and then by the edge of the Scale draw a line of the length of your first measured line, as you finde in your field-book 30 perches, 4 primes, which line let be A B.

Then

* Then place the Center of your protractor upon the Point B, in all respects as before, and finding your next degrees & length in your field-book to be 205 deg. 30 min. 26 perches, 7 primes, against 205 deg. 30 min. of your protractor, place your protracting pin, and apply the Scale of your protractor thereunto, the beginning of the divisions lying on the point B, and by the side thereof draw a line of the length of 26 perches, 7 primes, which is the line B C.

* And here you must note, that the lines belonging unto any number of degrees under 180 are to be drawn from the Center point downwards or towards you, and those lines that belong to any degree, above 180 are to be drawn from the Center-point upwards, or from you, as the last line B A, from the center-point B to A.

Now perceiving by your book that you are to leave the bounder that you went against, and finde this mark ⊙ there placed, (you must with black lead, or such like) make the same mark at the point C, and likewise a small dash with the pen, thus /, to signifie that you leave the bounder you last went against; then place the center of your protractor on the point C, as before, and finding your next degrees and lengths to be 130 degrees, 45 minutes, and 27 perches, 8 Primes, against these degrees of the protractor, place the protracting pin, and bring the edge of the Scale

of

of the Protractor from this point to C, the beginning lying upon C, and from the point C draw the line C D, of the length of 27 perches 8 primes, which because it belongeth unto a number of degrees under 180, is to be drawn downwards.

In this manner you must proceed with all the other lines and angles, as you finde them noted in your field book, til you come to incloſe at A where you began.

Having thus finiſhed your firſt incloſure, you muſt work in all reſpects with your ſecond and third, and ſo on, were there never ſo many. And to know where to begin to protract your ſecond incloſure you muſt have recours to your field book, where you ſhal find this mark ⊙ at the beginning of your ſecond Cloſe, & the like mark on your paper at the point C, which is your remembrancer to put you in minde that at the point C you muſt begin your ſecond Cloſe, which you muſt protract in all reſpects as you did the other.

Here note that you may take the plot of a Manor upon your Plain Table by helpe of the rules delivered in Chapter 39 and thoſe preceding, which will perform it with great facility and certainty, the practiſe whereof will be worth your time, and therefore I could wiſh you would make frequent uſe thereof.

Chap.

CHAP. LIII.

How to reduce a Plot to a greater or lesser quantity according to any proportion.

HAving protracted your plot according to the directions of the last Chapter, and if you finde it to be greater or lesser then your intended or confined limits, you may reduce it into a smaller or greater proportion according to the following doctrine.

For the effecting hereof you must provide a Ruler of what length you please, which must be divided into 100 equall parts and numbered as in the figure A B, and through the center A is a hole made to put in a small pin to fasten it to a Table so that it may be turned round about upon the Center A.

Now suppose you were to reduce the figure of the plot in Chapter 52, into halfe the bigneſſe it is now of. First you must fasten the Plot unto a Table at the four corners with mouth-glew or paſte, the

the right side of the plot lying uppermost, then lay another paper or parchment thereupon of your intended bigneſſe, faſtned likewiſe at the four corners unto the other plot, ſo that the center or middle of the leſſer plot may lie upon the center of the greater plot, about the midſt of your paper or plot place the center of your Ruler, through the center of which put a pin to faſten your two plots and your Ruler to the Table, ſo will your papers be faſt, and your Ruler will turn about according as you pleaſe.

Now to reduce your plot begin at A, unto which point bring your Ruler, and ſuppoſe that the point A meets with 98 degrees of the Ruler, now (becauſe the plot is to be reduced into halfe the bigneſſe) you muſt therefore take the halfe of 98, which is 49, and againſt that diviſion of the Ruler make a mark upon your paper with your compaſſes or pricking pin.

Then turn your Ruler about to B, which cutteth 90 degrees of the Ruler, the halfe whereof being 45, you muſt make a mark upon your paper, againſt 45 degrees of the Ruler.

Then turn your Ruler about to C, where it cutteth 92 degrees, the halfe whereof being 46, you muſt make a mark upon your paper, againſt 46 degrees of your Ruler.

Then bring your Ruler to D, where it cutteth 40 de-

20 degrees, the halfe whereof being 20, make a mark upon your paper against 20 degrees of your Ruler.

In this manner must you bring your Ruler to E, F, G, and H, and to all the other angles in the whole plot.

By these new marks you must draw lines upon your paper, as the lines AB, BC, CD, DE, EF, FG, GH, and HA so you shall have upon your new plot the exact figure of the field ABCDEFGH, according to a semi-proportion and thus must you doe with all the other Closes.

And when you come towards the middle of your greater plot, you must then unpaft two of the corners of your lesser plot, and fould it backwards the face of the new plot towards the face of the old, and by this means going over all the plot, you shall have the exact symmetry and proportion thereof upon your lesser paper.

In like manner if you were to reduce a plot from a smaller to a greater proportion, you must work according to the former directions, by doubling or trebling your numbers, *mutatis mutandis*, and and by this means you may most speedily and exactly perform the same.

Chap.

Chap. LIVI.

How to deck and beautifie your Plot after protraction.

YOur plot being protracted according to your intended bigneſſe, & written the content of each Cloſe about the midſt of the ſame, you may about the bounds of every field or incloſure, with a fine penſill and Sap green, neatly go over your black lines, ſo ſhall you have a tranſparent ſtroke of green on either ſide of your black line, which will adde a great luſtre and beauty to your plot.

Then in your Woodland grounds draw diverſe little Trees, in the moſt materiall places, and ſhadow your mountainous and uneven grounds with hils and dales, expreſſing all highwayes and Rivers diſtinguiſhing them by colours according to their ſimilitudes.

Then in ſome convenient place of the plot without the incloſures draw a Circle, and therein deſcribe the 32 points of the Mariners Compaſſe, ac-

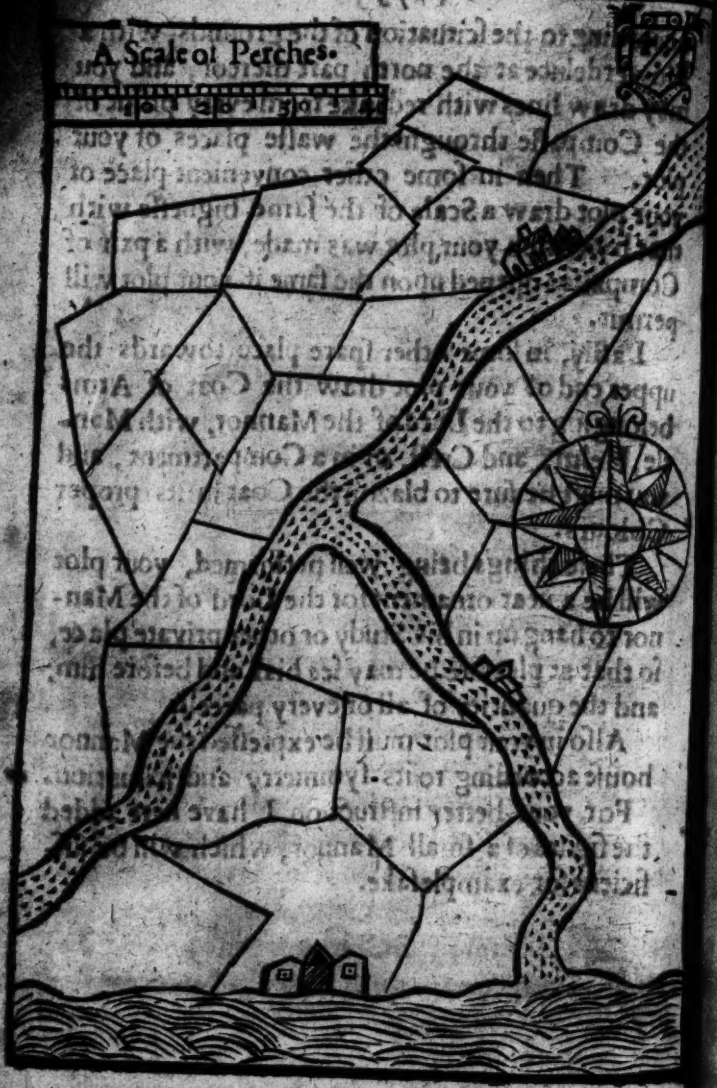
according to the ſcituation of the grounds, with a Flowerdeluce at the north part thereof, and you may draw lines with red inke from every point of the Compaſſe through the waſte places of your plot. Then in ſome other convenient place of your plot draw a Scale of the ſame bigneſſe with that by which your plot was made, with a pair of Compaſſes opened upon the ſame if your plot will permit.

Laſtly, in ſome other ſpare place towards the upper end of your plot draw the Coat of Arms belonging to the Lord of the Mannor, with Mantle, Helm, and Creſt, or in a Compartment, and you muſt be ſure to blazon the Coat in its proper Colours.

Theſe things being well performed, your plot will be a neat ornament for the Lord of the Mannor to hang up in his Study or other private place, ſo that at pleaſure he may ſee his Land before him, and the quantity of all or every parcell.

Alſo in your plot muſt be expreſſed the Mannor houſe according to its ſymmetry and ſcituation.

For your better inſtruction I have here added the figure of a ſmall Mannor, which will be ſufficient for example ſake.


A Scale of Perches.

An Appendix.

Shewing how the Content of most regular Figures may be attained: Also how to finde the Crassitude or Solid Content of any Timber, either standing or Squared.

Prop. 1.

To measure the Solidity of a Cube.

A Cube is a Figure comprehended under six equall sides, every side being a Geometricall Square, to finde the solidity whereof do thus, measure one of the sides, which multiply in it selfe, then that sum being again multiplyed by the side, shall give you the solid content thereof.

Example.

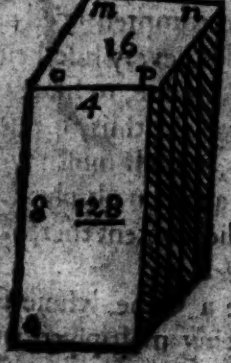
Let the figure ABCD be a Cube, whose side AB let be six foot, this 6 being multiplyed in it selfe

selfe, produceth 36, then multiply 36 by 6, and the product will be 216, and so many solid feet of Timber or stone are contained within the Cube ABCD.

Prop. 2.

To measure the solidity of a long Cube.

LEt MNOPQ be the figure of a long Cube or Oblong, the side whereof OP is four foot, which being multiplyed in it selfe giveth 16 foot for the Square MNOP, this 16 being multiplyed by 8 the length of the side OQ, giveth 128, and so many solid foot of Stone or Timber are contained in the whole figure MNOPQ.



Prop.

Prop. 3.

How to measure the solidity of a Cilender, or Piller.

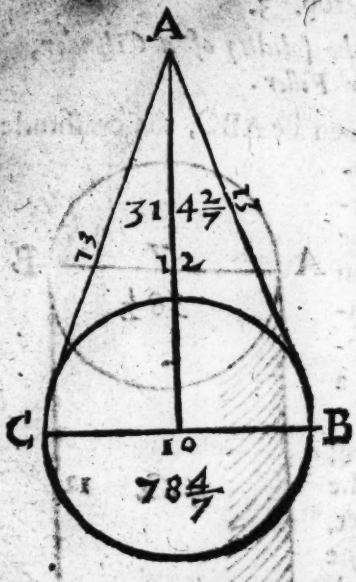
LEt the Cilender given be ABC, the crassitude whereof is required. Let the Diameter of the Circle at the end A B be 7 foot, then is the superficiall content thereof (by Chapter 43) 38 foot and a halfe.

This number being multiplyed by 12 the length of the Cilender, giveth 462 for the crassitude of the whole Cilender.

Prop. 4.

To measure the content of a Cone.

LEt the Cone given be ABC, the height whereof AC is 12 foot, and the diameter of the base CB is 10, by which the superficiall content



the Circle will be found to bee $78\frac{4}{7}$, which multiplyed by 4 the third part of the perpendicular, giveth $314\frac{2}{7}$ for the content required.

But by reason it is not easie to measure the altitude of a Cone, without the true knowledge of the perpendicular, I will therefore shew how that may be found, first, take halfe the diameter C B, which is 5, and multiply it in it selfe, makes 25, which number keepe, then measure the side C A 13, which multiplyed in it selfe makes 169, from which take the square of half the base which is 25, (your number before found) and there remains 144, the square Root whereof is 12, and that is he length of the perpendicular.

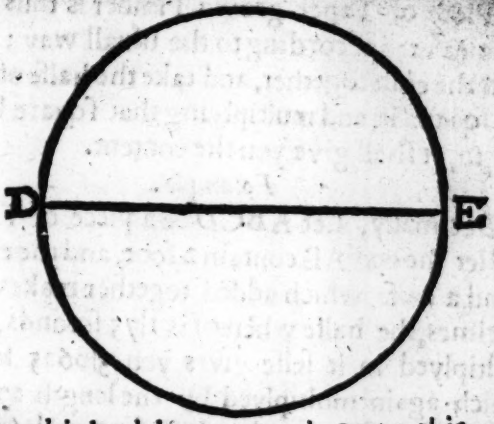
Prop. 5.

To finde the content of a Sphear.

CUbe the Diameter, which multiply by 11, and divide by 21, gives you the solidity. *Ex-*

Example,

In this figure let *D E* the diameter contain 14 inches, first, multiply 14 in it selfe, *facit* 196, which



again multiplyed by 14, giveth 2744, this number multiplyed by 11, maketh 30184, that divided by 21 is $1437\frac{2}{3}$ the content of the Sphear.

These are the common wayes of measuring these Figures, which for the present thou maist rest satisfied with, and shortly maist expect a Book now in the Presse entituled TACTOMETRIA, or *The Geometry of Regulars*. practically proposed, &c. which will shew the mensuration of Regular and Regular-like Solids, as also all regular Superficies, after a most artificiall, easie, and speedy manner not yet known: And withall the measuring and gauging of Vessels after the same way: And moreover the most exquisite way for the measuring of all irregular Bodies whatsoever, according to new experiments made for that purpose: With diverse other practicall conclusions in respect not only of Measure, but also of weight. All being usefull and delectable for all such as are studious of, or employed in Mathematicall practises.

Prop 6.

How to meaſure a piece of Taper-grown Timber.

A Piece of Taper-grown Timber is thus to be meaſured according to the uſuall way; Adde both the ends together, and take the halfe of them and ſquare it, and multiplying that ſquare by the length, it ſhall give you the content.

Example.

Decimally, Let *ABCD* be a piece of Timber, and let the end AB contain 2 foot, and the end *CD* 1 and a halfe, which added together makes 3 foot 5 primes, the halfe whereof is 1|75 ſeconds, which multiplyed in it ſelfe gives you 3|0625 fourths, which again multiplyed by the length 27, gives you 82|6875 fourths, that is 82 foot, and $\frac{6875}{10000}$ parts of a foot, for the content of the whole piece.

Prop. 7.

Another way to meaſure the ſame piece exactly.

EVery piece of Taper-grown Timber, the ſides thereof being extended would be a Piramis; As this piece *ABCD*, if the ſides AC & B*D* were extended till they met at E, they would include the Piramis AEB. Now to meaſure the ſegment *ABCD*, you muſt firſt find the length of the whole Piramis EF, thus: Subſtract 1|5 primes, the length *CD*, from the baſe, gives you 5 primes for the difference, then ſay by the rule of proportion.

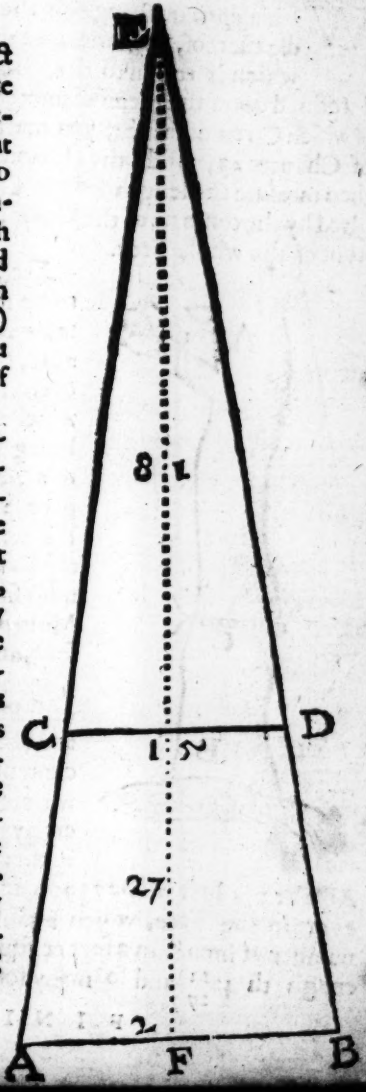
As the difference 5 primes, is to the baſe 2 foot: So is the length 27, to the whole length FE 108 foot.

Out

Out of which ſubſtract the length of the piece 27 foot, and there remains 81 for the height of the leſſer Piramis CED

2 The baſe AB ſquared makes 4 foot, which multiplyed by a third part of 108 (the length of the whole Piramis) which is 36 gives you 144 foot, the content of the whole Piramis.

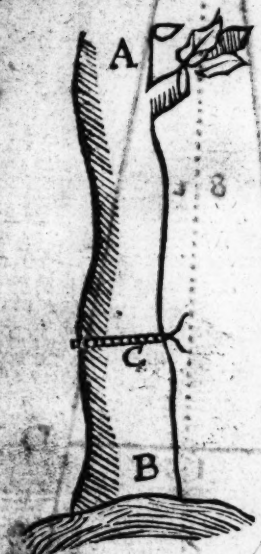
Laſtly, finde the content of the leſſer Piramis CED, by multiplying 1/5 primes the baſe CD in it ſelfe, and it maketh 2/25 ſeconds, which multiplyed by one third part of 81, the height of the leſſer Piramis 27, which makes 60/75 ſeconds, that is 60 foot and three quarters the content of the leſſer Piramis, which being deducted out of the whole Piramis the remainder will be 83/25 ſeconds, the true content of the piece ABC D.



Prop.

Prop. 8. *To measure any Timber Tree as it groweth.*

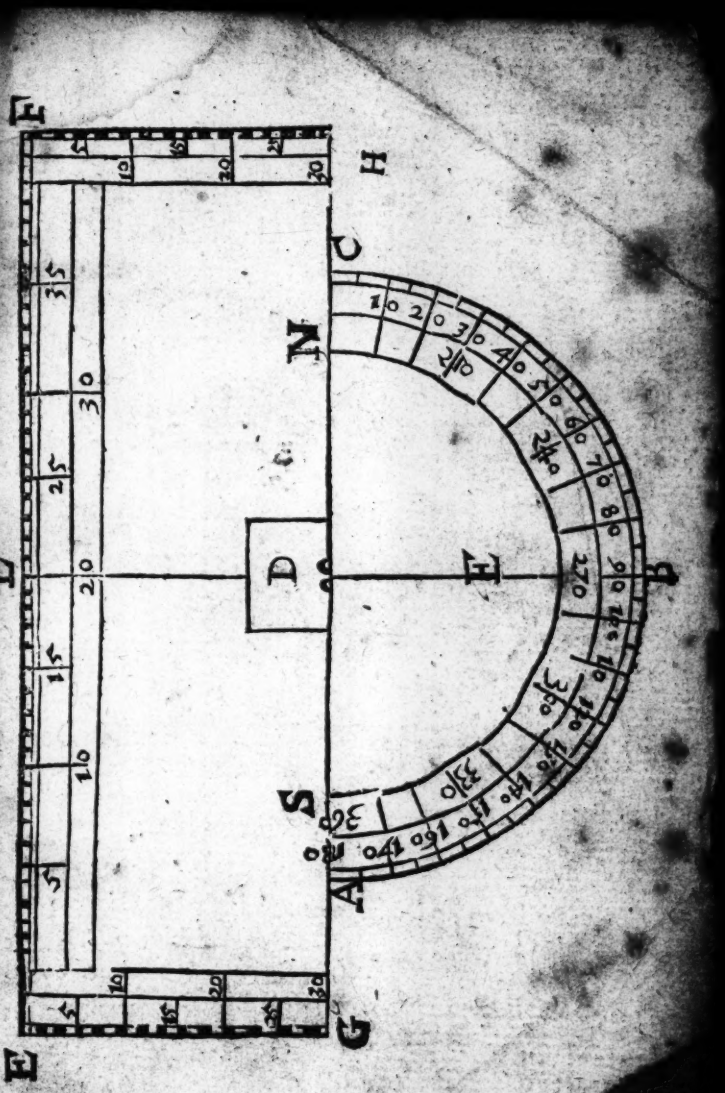
With a cord or string girt the Tree about the middle thereof, then measure the length of the string, which is equall to the circumference of a Circle described upon the mean diameter of the Tree, by help of which Circumference, you must, by the two last Rules of Chapter 43, finde the Diameter and Area thereof; then measure the length of the Tree, which being multiplyed by the content of the Circle, shall give you the content of the whole Tree.



Example.

Let AB be a growing Tree to be measured, first, girt the same about the middle thereof at C, then measure the length of the string, which let be 7 foot 4 inches, that is 88 inches, this being multiplyed by 7, gives 616, and 616 divided by 22, gives 28 for the length of the Diameter. Having attained the Diameter of the Circle, you must finde the area thereof thus, Multiply the Diameter 28 in it selfe, and it maketh 784, this again multiplyed by 11, produceth 8624, which divide by 14, and the quotient will be 616, the content of the supposed Circle, which content being multiplyed by 10 foot (which is 120 inches) the height of the Tree AB, the product will be 73920, and so many square inches are in the Tree, which again divided by 1728 (the number of inches in a foot of square Timber) the quotient giveth $42\frac{21}{27}$, and so many foot is in the whole Tree.

FINIS.



Let this be pasted upon the like figure